REPORT
of
TAIWAN AGRICULTURAL RESEARCH INSTITUTE
for the years
1946-1969

TARI LIB.
W007780

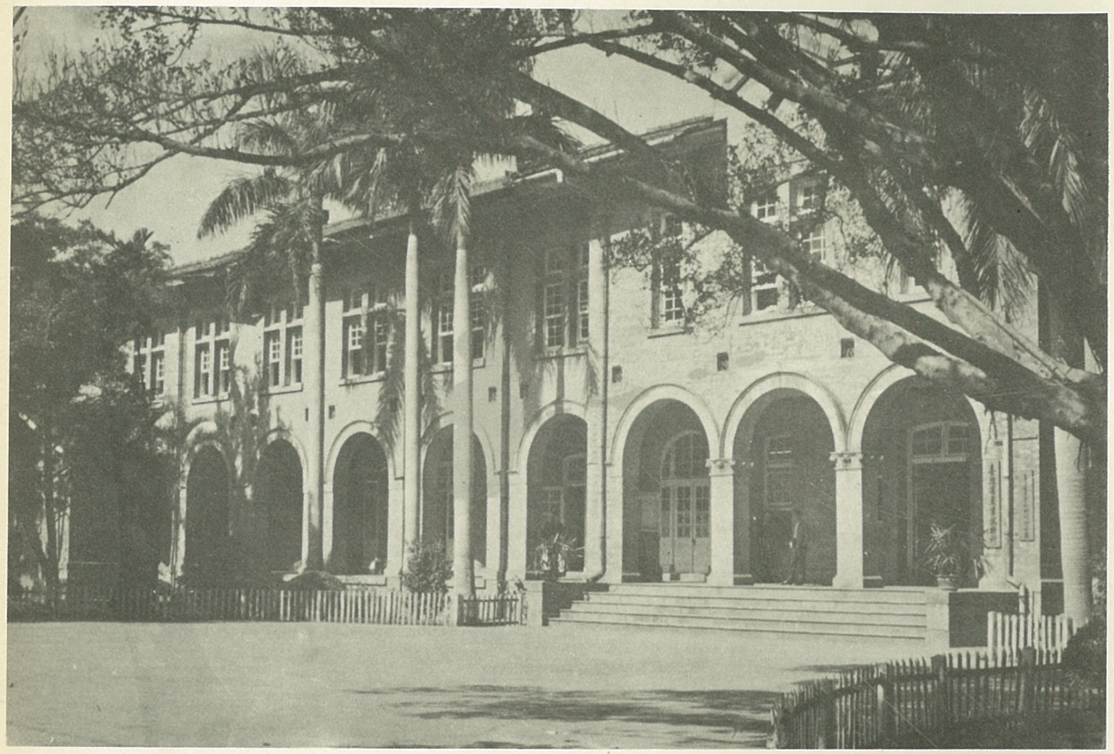
Published by

TAIWAN AGRICULTURAL RESEARCH INSTITUTE

TAIWAN, REPUBLIC OF CHINA

December, 1969

18680



The Main Building of TARI

REPORT
of
TAIWAN AGRICULTURAL RESEARCH INSTITUTE
for the years
1946-1969

Published by

TAIWAN AGRICULTURAL RESEARCH INSTITUTE

TAIWAN, REPUBLIC OF CHINA

December, 1969

PREFACE

Research activities which have been on the brewing in this Institute, since the end of World War II are briefly reviewed in this report. In the past years, our efforts have been mainly directed toward theoretical as well as practical researches in the fields of agronomy, horticulture, agricultural chemistry, plant pathology, applied zoology and agricultural engineering. Since many old problems being worked out would usually lead us to many more new ones, our activities in these fields have gained headway in recent years. A number of original papers, mostly written in Chinese, have been successively published either in our Journal of Taiwan Agricultural Research or in other scientific journals both at home and abroad. The contents of these papers are hereby presented in abstracts form for the reference of people who may be interested in them.

November 25, 1969

Shoei-chyuan Hsu, D. Ag.

Director,

Taiwan Agricultural Research Institute

CONTENTS

HISTORICAL 1
ORGANIZATION 1
ACTIVITIES 2
STAFF 3
FUNDS 4
EQUIPMENT AND FACILITY 5
POSITION, CLIMATE AND ELEVATION 6
SCOPE OF RESEARCH ACTIVITIES 7

I. Agronomy 7

A. Rice 7

1. Breeding of Rice Varieties 7
2. Yield Performance Forecasting Test of Rice 7
3. Introduction and Cataloging of Rice Varieties 8
4. Testing of Rice Varieties and Strains in the Uniform Blast Nursery 8
5. Interactions Between the Planting Seasons and Rate of Fertilizer Application in Rice 8
6. Effect of Split Application of Fertilizer on Yield, Components of Yield, and Other Agronomic Characters of Rice 9
7. Cultural and Fertilizer Dressing Methods Studies 9
8. Histological Studies of the Indica and Japonica Types of Rice 9
9. A Study on Hybridization Breeding Between Indica and Japonica Varieties of Rice 10
10. A Study on the Feasibility of Shortening the Breeding Period in Rice 10
11. A Study on the Efficiency of Bulk and Pedigree Methods is Hybridization Breeding of Rice 10
12. A Study on the Efficiency of Hybridization Breeding of Rice in Different Consecutive Seasons 10
13. Study of Breeding for Early-maturing and High Yielding Rice Varieties 11
14. Influence of Seedlings Age to Grain Yield of Indica Rice Varieties 11
15. Influence of Spacing to Grain Yield of Indica Rice Varieties 11
16. Effects of Tordon Herbicide on the Yield of Rice and Weeds Control in Paddy Field 11
17. Comparative Studies on the Effect of Selection in Hybrid Population of Rice under Different Fertilizer Levels 11

18. Comparative Study of Weed Control Methods in Rice 12
19. Effect of Growing Conditions on Grain Yield and Its Components in Rice....12
20. A Study on the Natural Region for Rice Breeding in Taiwan....13

B. Sweet Potato....13

1. Researches on Basic Problems of Sweet Potato....13
2. Varietal Improvement of Sweet Potato....14
3. Experiments on Sweet Potato Cultivation....14

C. Soybeans....15

1. Studies on the Characteristics and Chromosome Numbers of Some *Glycine* Spp.....15
2. Studies on the Method of Embryo Culture in the Cultivated and Wild form Soybeans....15
3. The Breeding of Rust Resistance Soybean Variety "Tainung 3"....15

D. Peanuts....16

1. Studies on the Genetic Behavior of Quantitative Characters in the Hybrid Progenies of Virginia and Spanish Peanut....16
2. Heritability of Hybrid Progeneies of Spanish and Virginia Peanut....16
3. The Analysis of Path Coefficient of Yield Components in Different Types of Peanut....17
4. The Path Coefficient of Yield Components of Peanut Growing in Different Seasons....17

E. Essential Oil Crops....18

1. The Effects of Mulch and Fertilization on the Yield of Grass, Oil Content and Oil Quality of Citronella Grass....18
2. The Effect of Fertilization on Citronella Grass....18
3. Spacing Experiment on Citronella Grass....18

F. Green Manure....19

1. The Effect of *Astragalus Sinicus* on the Growth of Rice on a Poorly Drained Soil....19
2. Demonstration of *Astragalus Sinicus* as a Winter Green Manure in Paddy Field....19
3. Studies on the Suitable Planting of *Astragalus Sinicus* as a Winter Paddy Green Manure and Its Influences to the Succeeding Crop of Rice....20

G. Cotton....21

1. Acclimatization of New Cotton Varieties....21
2. Pedigreed Pure-line Breeding....23
3. Hybridization Breeding....23
4. Improvement of Cotton Cultivation....23

H. Flax....24

1. Pollen Dissemination Study on Flax....24

2. Studies on the Development of Flax Fiber....24
3. Photoperiodism of Flax Varieties....25
4. Spinning Test of Flax Fibers....25
5. Natural Crossing Percentage of Flax....25
6. Improvement of Flax Varieties....25
7. Improvement of Flax Cultivation....26

I. Ramie....26

1. Improvement of Ramie Varieties....26
2. Improvement of Ramie Cultivation....27
3. Improvement of Fiber Processing....28
4. The Influence of Photoperiodism on the Development of Fiber Cells in Ramie....28

J. Jute and Its Substitutes....28

1. Improvement of Jute Varieties....28
2. Improvement of Jute Cultivation....29
3. Natural Crossing in Jute....31
4. Improvement of Kenaf....31
5. Improvement of Roselle....32
6. Studies on the Breeding Techniques of Jute and Kenaf....34
7. Studies on Yield and Quality of Fibers as Affected by the Time of Harvesting in Jute and kenaf....36

K. Sisal....36

L. Sunn Hemp....38

M. Kudzu....39

N. Researches on Crop Physiology....39

1. Studies on the Daily and Seasonal Variations of Photosynthetic Activities in Rice....39
2. Preliminary Study on the Relationship Between Photosynthesis and Yield of Rice....40
3. Comparative Studies on the Physio-chemical Characteristics of Indica and Japonica Types of Rice....40
4. Investigation on the Respiration Activity of Germinating Seed of Rice....41
5. Study on Daily and Seasonal Changes of Nitrogen Absorption of Paddy Rice....41
6. Comparative Study on Composition Outstanding Varieties of Rice in Taiwan....41
7. Effect of Manure Amount on N,P and K Content between Straw and Node of Rice Plant....42
8. Comparative Studies on Different Varieties of Rice Regarding Water Absorption at Various Growth Stages....42

9. Study on Photoperiodic Response of Rice Plants ····43
10. Observation on Differentiation of Floral Bud of Rice under Natural Condition ····43
11. Studies on Rotational Irrigation of Paddy Rice ····43
12. Study on Physiological Causes of Different Yield of Rice between First and Second Crop in Taiwan ····44
13. Studies on Immediate Cause of Akgagare Disease of Rice Occurred in Middle and South Taiwan ····45
14. Water Absorption by Sweet Potato as Influenced by Some Environmental Factors Observed at Taichung Taiwan During the Course of Solar Eclipse on Cloudy Day ····46
15. Studies on Physiology of Jute, Kenaf and Roselle····47

O. Researches on Genetics and Cytogenetics ····48
1. Studies on the Behavior of Chromosomes in Tetraploid Rice Plant ····48
2. Studies on the Development of Embryosac and Pollen Grain in Tetraploid Rice····48
3. Studies on Behavior of Chromosomes and Development of Embryosacs and Pollen Grains in Haploid Rice Plant····49
4. Cytological Studies of Sterility in Hybrids between Distantly Related Varieties of Rice *Oryzae Stativa*, L.····49
5. Isolation of Reciprocal Translocation Lines in Rice····49
6. Analysis of Reciprocal Translocations in Rice ····50
7. Studies on Agronomic Characters in Reciprocal Translocation Homozygotes of Rice ····50
8. Studies on the Growth and Development of Rice Embryo Cultivated in *Vitro* ····50
9. Analysis of Linkage Groups by Reciprocal Translocation Method ····51
10. Inheritance of Resistance to Different Races of *Piricularia Oryzae* ····51
11. Genic Analysis for Purple Pericarps and Other Characters in Rice ····52
12. Inheritance of Mutations Induced by Irradiations in Rice····52
13. Linkage Relations of an Induced Dwarfness Gene ····52
14. Inheritance of Resistance to Phytotoxicity of Phenyl Mercuric Acetate in Rice ····53

P. Irradiation Experiments ····53
1. Irradiation Experiment on Rice ····53
2. Effects of X-rays and Thermal Neutrons on Chromosomes of Rice ····55
3. Rice Breeding Utilizing Irradiated Rice Material ····55
4. Irradiation Experiment on Peanut ····55
5. Irradiation Experiment on Sweet Potato ····55
6. Irradiation Experiment on Soybean ····56
7. The Effects of X-ray and Thermal Neutron Irradiations on Soybean ····56

Q. The International Exchange of Seeds and Seedlings of Crops in Taiwan····57

II. Horticulture ····59

A. Experiments on Fruit Trees ····59
1. Pineapple ····59
2. Banana ····60
3. Citrus Fruit····61
4. Mango ····63
5. Coffee ····64
6. Other Fruits····64

B. Experiments on Vegetable Crops ····65
1. The Preparation and Test of Antiserum to Potato Virus X ····65
2. Test on the Seed Production of Kinmen Early Kohlrabi ····65
3. Studies on Chemical Regulation upon Vegetable Crops ····65
4. Breeding of Cauliflower ····66
5. Breeding of Tomatoes ····66
6. Breeding of Watermelons ····66
7. Introduction of Other Vegetable Crops ····66
8. Segregation and Selection of Vegetable Varieties ····67
9. To Hasten the Setting Period of Onion Seedlings····67
10. Test on Sowing of Onions····67
11. Deciding the Standard Planting Distance of Onions····67
12. To Investigate the Promoting Production Factors of Potatoes····67
13. Influencing Factors on the Fruit Quality of Triploid Watermelons ····68

C. Experiment on Flowers ····68
1. Experiment on Cross Breeding of Orchid····68
2. Improving Experiment on Various Kind of Flowers ····68

III. Agricultural Chemistry ····70

A. Soil Survey (General Survey of Soil)····70

B. Land-use Capability Survey of Marginal Zone between Forest Land and Crop Land in Taiwan ····70

C. Fertilizer Researches ····71
1. A Study on the Application of Calcium Cyanamide for Rice ····72
2. Experiments on the N-P-K Requirements for the Main Crops of Taiwan ····72
3. A Study on the Relative Availability of Ammonium Sulphate, Ammonium Chloride, Calcium Ammonium Nitrate and Urea to Rice ····72
4. A Study on the Tungshan Paddy Soil ····72
5. A Study on the Method of Application of Urea on Rice ····72

6. Studies on the Effect of Silica on Paddy Rice ····72

D. Plant Nutrition ····73

1. Studies on Nutrient Absorption of Rice Plants in Taiwan ····73
2. Lysimeter Experiment on Paddy Soils ····74
3. Study on the Growth of Rice Plants in Ill-Drained Paddy Soils····74
4. Studies on Plant Analysis as a Guide for Corp Fertilization ····74

E. Soil Fertility ····74

1. Soil Tests for Crop-land of Taiwan ····74
2. Calibration Study on Soil Tests ····75
3. Study on Increasing Rice Production of Newly Converted Paddy ····75
4. Soil Tests Carried Out in 1950····75
5. Field Experiments on N-P-K Requirement for Rice ····75

F. Soil Physics ····76

1. Study on Erodibities of Soils on Hilly Lands in Taiwan ····76
2. Study on Moisture Retension of Taiwan Soils ····76

G. Soil Chemistry ····76

1. Study on Soil Development of Reddish Brown Lateritic Soils in Penghu Hsien, Taiwan····76
2. Comprehensive Study on the Genesis of Reddish Brown Latosols in Taiwan ····77

H. Soil Microbiology····77

1. Study on Nodule Bacteria of Leguminouns Plants····77
2. Study on Reducing Bacteria in the Sick Soils of Paddy Fields····77

I. Chemistry of Agricultural Products ····77

1. Foundation of Food Dehydration Industry was Laid ····78
2. Processing of Canned Fruit Cocktail ····78
3. Dehydration of Onions····79
4. Dehydration of sweet and Hot Peppers ····79
5. Quantitative Analysis of Vitamin C Containing in Fruits····80
6. Miscellaneous Works on Processing ····80

IV. Plant Pathology····81

A. Rice Diseases ····81

1. Studies on the Rice Blast Disease····81
2. Annual and Local Variation of the Varietal Resistance of Rice to the Blast Disease ····81
3. The Effect of Cultural Filtrate of *Pyricularia Oryzae* and Colletotricum Corchorum to the Disease Control ····81
4. The Relation of Seedling Reaction and the Leaf Blast of Field Stage ····81
5. The Effect of Fertilization and Chemicals on the Outbreak of Rice Blast ····81
6. Studies on the Physiological Specialization of *P. Oryzae* ····81
7. Nutrition of the Rice Blast Fungus, *Pyricularia Oryzae* Cav. ····81
8. Rice Seed Disinfection for Disease Control····81
9. Chemical Control of the Rice Blast ····82
10. Chemical Control of the Seath Blight ····82
11. Relation of Fertilization and Rice Varieties to an Outbreak of the Sclerotial Diseases ····82
12. Studies on the Bacterial Leaf Blight ····82

B. Sweet Potato Diseases ····82

1. Comparison of the Disease Resistance Among the Sweet Potato Varieties····82
2. Research on Internal Cork of Sweet Potato ····82
3. Survey on the Sweet Potato Diseases····82
4. Control on Bud Atrophy of Sweet Potato ····82
5. Research on the Storage Diseases of Sweet Potato ····83

C. Fiber Crop Diseases····83

1. Studies on the Control of Cotton Diseases ····83
2. Studies on Diseases of Main Long Fiber Crops and Their Control ····83

D. Oil Crop Diseases····84

1. The Effect of Seed Treatment to the Control of Southern Blight of Peanut ····85
2. Chemical Control on Soybean Rust ····85
3. Studies on the Physiological Race of Soybean Rust Fungus ····85
4. Chemical Control of Purple Stain and Soybean Rust····85
5. Bacterial Blight of Soybean Disease ····85

E. Citrus Diseases····85

1. Survey on the Black Spot Disease of Citrus ····85
2. Studies on Citrus Black Spot ····85
3. Chemical Control of Citrus Scab ····86
4. Chemical Control of Citrus Greasy Spot ····86
5. Time and Duration of Citrus Leaf Infection by Greasy Spot Fungus ····86
6. Nematological Studies ····86
7. Method of Pineapple Mealybug-wilt Control is being Carried on in Demonstration and Extension ····86

F. Vegetable Diseases ····86

1. Maintenance of Virus X Free Potatoes····86
2. Seed Treatment for Control of Southern Blight of Kidney Bean ····86
3. Seed Dipping for Control of Cabbage Black Rot ····87
4. Survey on the Asparagus Diseases····87
5. Pathogenicity of the Causal Fungus of Asparagus Stem Blight ····87

6. Fungicidal Screen Tests for Control of Asparagus Stem Blight ····87

G. Medical Herb Crops Diseases ····87

1. Survey on the Mint Diseases ····87
2. Chemical Control of Mint Powdery Mildew ····87
3. Chemical Control of Mint Rust ····87

H. Studies on the Mushroom ····88

1. Varietal Selections of Mushroom ····88
2. Comparison of the Vitality of Mushroom Multiplied by Spores and Tissues ····88
3. Study on the Methods of Preserving Desirable Mushroom Varieties····88
4. Mushroom Disease····88

I. Miscellaneous Studies on Diseases of Vegetable and Fruit ····89

V. Applied Zoology ····90

A. Insect Collection ····90

B. Insect Taxonomy····90

C. Useful Insects and Snails····90

1. Beneficial Snails ····90
2. Natural Enemies of the Phytophagous Mites ····91
3. Lac Insect····91
4. Natural Enemies of Citrus Insects ····92

D. Insect Pests and Their Control ····93

1. Paddy Borer, *Tryporyza Incertulas* Walker and Brown Plant Hopper, *Nilaparvata Lugens* Stal ····93
2. Soybean Insects ····94
3. Sweet Potato Insects····94
4. Cotton Insects····95
5. Jute Insects ····95
6. Kenaf Insects ····96
7. Flax Insects····96
8. Sisal Insects····96
9. Stored Grain Insects····96
10. Citrus Insects ····97
11. Banana Insects ····98
12. Litchi Insect ····99
13 Mango Insect ····99
14. Cruciferous Insects····99
15. Melon Insect ····100
16. Mushroom Pests····100
17. Phytophagous Mites ····101
18. Miscellaneous Studies on Insect Pests of Vegetable and Fruit ····102

E. Insecticide Toxicology ····102

1. Manufacturing Rotenoid Emulsion ····102
2. Insecticide Toxicology ····103
3. Oral Toxicity of Lindane and Its Tolerance to Poultry and Mice ····103
4. Insect Resistance to Insecticide····104
5. Bioassay of Pesticide Residue on or in Vegetables····104
6. Sumithion and Parathion Residues on Rice and Green-Stem Cabbage ····104
7. The Removal of Parathion Residues from Cabbage Leaves by Washing and Cooking ····104
8. Bioassay of Marketing Pesticides ····105

VI. Agricultural Engineering ····106

A. Experiments and Study on Power Tillers ····106

B. Experiments and Study on Hand Rice Cutters and Portable Power Rice Cutters ····106

C. Experiments and Study on Rice Combines ····106

D. Experiments and Study on Circulation Dryer····106

E. Experiments and Study on Power Tillers and Tractors ····107

F. Study of Fiber Processing Machines ····107

G. Testing of Fiber Qualities ····109

REPORT
of
TAIWAN AGRICULTURAL RESEARCH INSTITUTE
for the years
1946-1969

HISTORICAL

The agricultural research and experiment organizations of this province are attributed originally to the Agricultural Experiment Station founded in 1895, of Japanese Formosan Government. Thereafter, in 1921, through enlargement and reorganization, the Experiment Station became the department of agriculture of a new central organization called the Government Research Institute, which consisted of four departments dealed with agriculture, forestry, industry and public hygiene research work. In 1939, these departments of the Government Research Institute were separated into four independent institutions directly under the supervision of Japanese Formosan Government. The department of agriculture was then transformed into the Agricultural Research Institute.

After the conclusion of World War II, when Taiwan again became a Chinese province, the Institute was taken over and formally entitled as TARI in 1945. All of the structures in the Institute remained the same as they were before except the Department of Agricultural Engineering was formally established on January 1, 1964, and the animal husbandry research which had been suspended and it is now being under an independent institution since 1958.

ORGANIZATION

The Headquarters including four executive offices and six departments dealing with the various fields of research and experiment work is situated on an area of 63.1578 hectares in the suburb of Taipei city. Four Experiment Stations are distributed all over the province in accordance with the climatic and agricultural conditions where the particular research work could be best carried out. The present organization may be outlined as follows:

Taiwan Agricultural Research Institute
- Department of Agronomy
- Department of Horticulture
- Department of Agricultural Chemistry
- Department of Plant Pathology
- Department of Applied Zoology
- Department of Agricultural Engineering
- Office of Administrative Inspection
- Office of General Affairs
- Office of Accountant
- Office of Personnel Affairs
- Shihlin Horticultural Experiment Station
- Chiayi Agricultural Experiment Station
- Tainan Fiber Crops Experiment Station
- Fengshan Tropical Horticultural Experiment Station

ACTIVITIES

TARI

(1) Research on crop improvement including breeding, culture method.
(2) Investigation on plant physiology, genetics and cytogenetics.
(3) Soil survey, soil microbe and plant nutrition researches, testing of soil fertility and crops for fertilizer requirement.
(4) Chemistry on agricultural products and nutrio-physiological problems of rice plants.
(5) Research on insects classification, insecticides, beneficial insects, plant diseases and insect pests control.
(6) Improvement of farm machinery and implements.

Shihlin Horticultural Experiment Station

Research on orange, vegetables, orchids and flowers.

Chiayi Agricultural Experiment Station

Research mainly on rice, sweet potato and fruit trees, and has the longest record of working on sweet potato breeding and multiplication in Taiwan.

Tainan Fiber Crops Experiment Station

Research in fiber crops breeding and cultivation, in plant protection of fiber crops, in business of ginning; and demonstrates excellent varieties and methods of cultivation and other extension work in localities selected by the Provincial Department of Agriculture and Forestry.

Fengshan Tropical Horticultural Experiment Station

Research on pineapple, vegetable, and dehydration Processing, but emphasizes programs on breeding, cultural improvement and multiplication of pineapple and vegetable.

STAFF

I. Headquarters

Director

Shoei-chyuan Hsu, D.Ag.

Members

1. Department of Agronomy
   Sung-ching Hsieh, D.Ag., Head of Department
   Cheng-sheng Huang, Ph.D., Lab. of Rice Crop
   Yung-yu Yang, B.Sc., Lab. of Special Crops
   Chen-nen Wu, B.Sc., Lab. of plant physiology
   Sung-ching Hsieh, D.Ag., Lab. of Cytogenetics
   Chen-shiu Lin, Div. of Farm Management
2. Department of Horticulture
   Pe-nien Lee, Head of Department
   Mong-yu Yen, B.Sc., Lab. of Pomology
   Pe-nien Lee, Lab. of Vegetable Crops
   Jen-lu Weng, Lab. of post Harvesting
3. Department of Agricultural Chemistry
   Ku-wing Leung, B.Sc., Head of Department
   Ku-wing Leung, B.Sc., Lab. of Soil Chemistry
   Lanti Li, B.Sc., Lab. of Soil Physics
   Shen Lian, M.Sc., Lab. of Fertilizer Research
   Chun-chuan Chen, B.Sc., Lab. of Soil Fertility
   Ching-teh Lin, B.Sc., Lab. of Soil Microbiology
   Tsai-fua Chiu, M.Sc., Lab. of plant Nutrition
   Ping-chen Lin, B.Sc., Lab. of Chemistry of Agricultural Products
4. Department of plant pathology
   Kai-jen Hu, B.Sc., Head of Department
   Chin-chung Chien, Lab. of Rice Disease
   Tsu-chang Dough, Lab. of Horticultural Crop Disease
   Kai-jen Hu, B.Sc., Lab. of Edible Mushroom Research
5. Department of Applied Zoology
   Shui-chen Chiu, B.Sc., Head of Department
   Kwei-shui Lin, Lab. of Systematic Entomology
   Sung-lien Lee, M.Sc., Lab. of Bioassay and Insect Toxicology
   Chia-chu Tao, Lab. of Destructive Insects
   Shui-chen Chiu, Lab. of Beneficial Insects
6. Department of Agricultural Engineering
   Ching-piao Wu, B.Sc., Head of Department

II. Shihlin Horticultural Experiment Station

Wen-po Feng, B.Sc., Director
Shu-tao Lu, B.Sc., Head, Department of Vegetables and Flowers
Hung-lan Lee B.Sc., Head, Department of Fruits

III. Chiayi Agricultural Experiment Station

Mau-kang Wang, Director
Wan-lai Chang, M.Sc., Head, Department of Agronomy
Ching-kuo Chu, B.Sc., Head, Department of Horticulture
Chia-hwa Tao, Head, Department of plant protection

IV. Tainan Fiber Crops Experiment Station

Ching-yuang Chi, B.Sc., Director
Kuang-tou Hsiung, B.Sc., Head, Department of Fiber Crops for Clothing Uses
Ming-li Lai, B.Sc., Head, Department of Fiber Crops for industrial Uses
Ti-chuan Chen, Head, Department of Fiber Machinery
Chin-chyu Tu, M.Sc., Head, Department of plant protection

V. Fengshan Tropical Horticultural Experiment Station

Chung-hsiung Yu, B.Sc., Director
Chao-chuan Wang, B.Sc., Head, Department of Tropical Horticulture
Ching-fu Chen, B.Sc., Head, Department of Processing of Horticultural Products
Tsan Huang, M.Sc., Head, Department of Plant Protection

FUNDS

Research is financed by funds appropriated annually by the Taiwan Provincial Government which are generally insufficient to meet the actual expenditures. Therefore, efforts have been made to acquire subsidies from outside sources in which respect the Institute received much of its financial support in the form of grant-in-aid through contracts of research project with the JCRR to increase necessary supplements of laboratories, libraries and to build greenhouses.

Through research project, the Institute also obtained grants from foreign organization and domestic enterprises such as USDA, IRRI, Taiwan Provincial Food Bureau and Taiwan Fertilizer Company, etc..

In the fiscal year 1969, the funds provided for TARI, exclusive of its branch stations are as listed in following table:

Unit : NT$

Sources / Funds / Department	Taiwan Provincial Government	JCRR	Total
Agronomy	641,405	1,503,147	2,144,552
Horticulture	154,680	934,100	1,088,780
Agricultural Chemistry	664,422	379,820	1,044,242
Plant Pathology	587,980	1,764,500	2,352,480
Applied Zoology	395,365	3,053,442	3,448,807
Agricultural Engineering	247,430	36,720	284,150
Total	2,691,282	7,671,729	10,363,011

Note : (1) The total amounts to NT$ 10,363,011 exclusive of the expenditure for administration and personnel in the table.

(2) In the fiscal year 1969, the Institute obtained NT$ 991,540 from USDA, Taiwan Provincial Food Bureau and others in addition to the amount in the table.

EQUIPMENT AND FACILITY

The equipment and facilities now we have in this Institute are almost all procured or installed during the last twenty four years after the restoration of Taiwan. It can be grouped as follows:

1. Land

Total land area amounted to 63.1578 hectares, including paddy field, 9.1193 hectares, dry farm land 12.3452 hectares, forest land 24.4100 hectares, land for construction and building 15.8182 hectares, other 1.4651 hectares.

Part of these land areas were leased to some military agencies, therefore, the land area available for experimenting purpose at present time amounted to only 11.9595 hectares, of which 7.1630 hectares belong to paddy field and 4.7965 hectares dry farm land.

2. Buildings and Constructions

This Institute has 141 buildings, including headquarter office, 25 buildings for various research department, 23 buildings for special research purpose, such as: greenhouse, weather station, insect museum, insectary, soil testing hall and agriculture machinery work shop etc., 14 warehouses, 65 residences and 13 other buildings. In 1954, all the damages of the gas piping system has been repaired with the subsidies from JCRR.

3. Library and Instruments

There are about 31,169 volumes of books, magazines and other reference materials in the Institute's library through exchanging with foreign agencies, procurement with our own fund or subsidies from JCRR.

The Institute is equiped with many fundamental instruments and laboratory facilities. There are 1,383 pieces of instruments and machineries and many other experimental tools and devices. To name just a few: spectrophotometer, four wheel power tiller, combine, grain fertility tester, aerograph pestilizer, gas chromatograph, high speed centrifuge, growth chamber, isotope apparatus, polarographic apparatus, ultroviolet & vissible spectrophotometer, atomic absorption spectrophotometer, precision chemical balance, frame photometer, binocular microscope, refrigerator (temperature automatically regulated), soil testing kit, electro-photometer, pH meter(glass electrode), centrifuge, muffle, platinum crucible, polarimeter, incubator (constant temperature, constant humidity), waterbath, electronic calculator, sterilizer(high pressure), microtome, blender, sprayer and projector, etc..

POSITION, CLIMATE AND ELEVATION

The area served of our Institute is the whole of Taiwan province. Taiwan lies in the Western Pacific to the southeast of China mainland shaped like a banana leaf. The island is long and narrow. It is 380 kilometers between north and south and 140 kilometers between east and west. Across the Taiwan straits to the west, Taiwan faces the Fukien Province on the mainland. The island is strategically linked to the Philippines across the Bashee straits in the south and the Rhykyus in the northeast.

In general, the island has tropical and subtropical climates which are influenced by ocean currents and wind. The annual average temperature is 22°C, average annual humidity is around 80%, and average annual evaporation is 1,500mm, average rainfall is 2,500 mm. However, there is a remarkable temperature change with relief. The relationship of the mean annual temperature and the elevation is shown below:

Place	Average annual temp.	Elevation
Taipei (in the north)	21.7°C	basin
Henchun (in the south)	24.4°C	basin
Mountain Yangmin	16.2°C	667M (above sea level)
Mountain Ali	10.6°C	2,406M(above sea level)
Mountain Morrison	4.0°C	3,950M(above sea level)

SCOPE OF RESEARCH ACTIVITIES

I. Agronomy

The main crops cultivated in Taiwan, including rice, sweet potato, peanut, soybean, jute, ramie, cotton, kenaf and flax etc. were studied in this Institute in past twenty four years from different view points, such as plant breeding, method of cultivation, plant physiology, genetics and cytogenetics. The brief review of research activities on these crops is made in the following paragraphs.

A. Rice

1. Breeding of Rice Varieties

The rice breeding work in our Institute was started in the early period of Japanese occupation, and many improved rice varieties commercially known as the Ponlai rice (Japonica type) such as Tainung No. 38 and Tainung No. 45 etc. were bred in the Agronomy Department of the Institute.

Since the restoration of Taiwan to China, a number of new Ponlai varieties such as Tainung selection No.1. 2 and 3 and Tainung No. 60 were registered. Tainung selection 1 and 2 are drought resistant which is fairly acceptable in upland rice area of northern and central part of the island. Tainung selection 3 is an early maturing variety that is grown mostly in the central part of Taiwan, but is still a minor variety.

Rice blast is the most prevalent and destructive disease of rice in Taiwan, particularly in the first crop when the environmental conditions are more favorable for its occurrence. The annual loss from this disease was estimated to be not less than 5% of the total production. Therefore, the problem of effective control of the blast is very important. Chemical control of blast in rice is not only expensive but provides only temporary protection. The development of resistant varieties offers a more satisfactory and permanent solution to this problem.

The Chiayi Agricultural Experiment Station has been noted for its severe and uniform occurrence of the blast disease. Taking advantage of this natural epiphytotics, an intensive program of breeding rice varieties for blast resistance has been carried out at this Station during the past two decades. Resistant introductions from the United States, Japan, IRRI and other countries are used as parental materials to incorporate the disease resistance into the local susceptible varieties. Selection is made in disease nursery set up under both paddy and dry field conditions. During the past years, two blast resistant varieties, Kuang-fu 1 and Chianung 242, have been released by this Station for general cultivation, and a few selections are currently under various stages of yield testing.

2. Yield Performance Forecasting Test of Rice

Based upon the records of 28 years (from 1941 to 1968), the close correlations between the following meteorological factors and yield were found.

(1) Negative correlation is found between the amount of rainfall in June (at the maturity of the lst crop) and the yield of lst crop. The same is true between the

rainfall in October (at the maturity of the 2nd crop) and the yield of 2nd crop.

(2) Positive correlation is found between the total amount of sun light and the yield of lst crop, i.e. the greater amount of sun light available, the higher yield of the lst crop will be. This relationship has been very conspicuous.

3. Introduction and Cataloging of Rice Varieties

More than 3,000 varieties were introduced from foreign countries including other provinces of the Republic of China, Japan, Southeast Asia, the United states, Europe etc.. These varieties were carefully observed, and unfavorable mixed varieties were discarded. A total of about 2,500 varieties were kept in cold storage room. The characteristics of each variety were described in "A monograph of rice varieties preserved by Taiwan Agricultural Research Institute" published in 1964.

4. Testing of Rice Varieties and Strains in the Uniform Blast Nursery

A total of 161 varieties, selections, and lines were tested for reaction to composites of races of the blast fungus in the uniform blast nursery of the Chiayi Agricultural Experiment Station during 1956–1964. Forty out of 161 entries were found to have similar or higher resistance to leaf blast than the resistant check variety, Chianung 242. Among them, 5 were highly resistant, 25 resistant, and 10 moderately resistant. Only 3 commercial varieties were resistant while the other 19 were susceptible to leaf blast. Twenty nine out of 33 entries resistant to leaf blast were also resistant to neck blast and the remaining 3 were susceptible. Among 21 commercial varieties, 12 resistant and 9 susceptible entries were recorded for neck blast infection.

In a large number of varieties and lines, the agreement between leaf and neck reactions was found to be generally good, although in certain entries, a lack of agreement was observed. A number of varieties and selections are resistant to leaf blast and are available for further rice breeding work. Chianung 242, a parent of many resistant selections, appeared to be an important source of resistance.

5. Interactions Between the Planting Seasons and Rate of Fertilizer Application in Rice

Three varieties: Taichung No. 65, Taichung No. 150 and Dan-kwang-hwa-loo; four fertilizer treatments: i.e. full rate, half rate, super rate and blank; and three transplanting periods: i.e. early (March 8), medium (March 15) and late were employed. Results indicated that for early transplanting the crop responded regularly to fertilizer levels being best at the super rate, followed by the full rate, half rate, and blank. For the medium and the late transplanting periods, no apparent response to the various levels of fertilizer application could be found, except for the blank in which the yield of each variety showed some differential responses to the various treatment combinations, The yield of Taichung No. 65 was the most consistent one. Without reference to the factor of planting periods, the varieties Dan-kwang-hwa-loo and Taichung No. 65 all yielded more than the Taichung No. 150. Difference in yield between early and medium planting periods did not show any significance, which demonstrated that the period from March 8 to 15 may be considered as a proper time for transplanting. If the planting period were delayed until March 26, the growth and the yield of rice would

be more or less restrained even more fertilizers were applied.

6. Effect of Split Application of Fertilizer on Yield, Components of Yield, and Other Agronomic Characters of Rice

The effects of time of fertilizer application on yield, components of yield, and some important characters of rice has been under investigation at Chiayi Station since 1963, with a simple objective of improving the efficency of fertilizer utilization by rice plant. Experimental results obtained so far indicated that split application of nitrogen and potassium fertilizers was generally effective in raising grain yield in both the first and the second crops of rice, whereas split application of phosphorus fertilizer did not show any significant increase in grain yield of rice. Since panicles per hill is the most important component influencing grain yield, and rice plants generally produce more panicles per hill in the first crop, it appears necessary that more nitrogen should be applied at the early stage of growth in less splittings in order to prevent a drastic decline of effective tillers in the first crop. In the second crop, however, the environmental conditions are not favorable for rice plants to produce more panicles per hill, but are rather favorable for producing longer and heavier panicles with more grains per panicle, it seems desirable that nitrogen should be applied in more splittings with more emphasis placed at the late stage of growth.

7. Cultural and Fertilizer Dressing Methods Studies

The climate of Taiwan is characterized with high temperature and abundant rainfalls, hence the fertilizers applied to rice crops, are relatively easy to be leached. Comparisons of the various methods of fertilizer placement to the conventional method of surface dressing of fertilizers were thus made. Treatments consisted of plowing with depths of 10 cm, 15cm, 20cm, 30cm, and 35cm; fertilizer dressed in both layers (oxidation and reduction layears) of the soils, in oxidation layer only, and on surface. According to the results obtained from the experiment, the yields were both higher in plots with plowing depths of 20 cm and 30cm, and fertilizers dressed in both layers or in oxidation layer only, than the plots with conventional practices (i.e. plowing depth 15 cm and suface dressing).

8. Histological Studies of the Indica and Japonica Types of Rice

Histological studies on the roots, stems and leaves of both indica and japonica type rice were made, Results showed that:

(1) There is a tendency to have more tracheas in roots of the indica type than that in the japonica type. It seems that there existed some agreements connected with the conclusion drawn by the previous investigations to which they pointed out the greater number of vascular bundles in stems of the indica rice. It might be explained partially as a reason why the indica type of rice is more adaptable to poorer soils. In glutinous rice varieties, their tracheae and central cylinders also tended to be greater. No appparent anatomical difference could be found in the root periderm and in the thickness of sclerenchymatous tissues among the rice varieties.

(2) In roots of the native rice, indica type, the proportion in the number of trachea, the area of central cylinder, to area of whole root tended to be slightly greater

than that in the roots of japonica type.

(3) The stems of the native rice were coarser and the number of vascular bundles in the inner and outer layers were greater. Such differences were less conspicously seen in the part of rachis. Their vascular bundles were larger and more widely scattered. But their mechanical tissues (lower epidermis and pericycles) were better developed in rice of the japonica type.

(4) With respect to leaves, there was a tendency for the native rice (indica type) to have wider and thinner leaf blades with more but smaller stomata. Their number of vascular bundles was also greater. At the same time the small-sized vascular bundles were smaller and arranged in a more compact way. The mechanical tissues located both at lower and upper side of the vascular bundles were also narrower and smaller.

9. A Study on Hybridization Breeding Between Indica and Japonica Varieties of Rice

More than 50 crosses between japonica varieties (ponlai varieties only) and indica varieties were made, and sterility and other agronomic characters of F_1 and F_2 as well as F_3 generations were studied. The result was reported in separated paper.

10. A Study on the Feasibility of Shortening the Breeding Period in Rice

Two rice crops per year are grown in Taiwan, however, if three crops are grown in a year, the period of time in developing a new variety through hybridization can be shortened. Under this idea, the segregating plant materials of four crosses between indica and japonica. Varieties were grown on seed bed in green house (not heated) in three crops per year to test the feasibility. The result indicated that unless green house was heated in winter, it seemed impossible to grow three rice crops a year in Taipei. Too low temperature in winter was the limitting factor.

11. A Study on the Efficiency of Bulk and Pedigree Methods in Hybridization Breeding of Rice

Segregating plant materials of two crosses, one between japonica and indica the other between two japonicas, were handled in bulk and pedigree methods. The selected strains from both methods were yield tested. The result indicated that the strains selected from bulk method had higher variability in several agronomic characters including grain yield. In other words, the bulk method is probably more efficient in selecting desirable strains than the pedigree method within the materials used.

12. A Study on the Efficiency of Hybridization Breeding of Rice in Different Consecutive Seasons

Due to different environments of the first and second crop seasons in Taiwan, the strains selected consecutively in different seasons may bring about higher adaptability to different seasons. Under this idea, the segregating plant materials of two crosses were grown separately in the first crop season consecutively, in the second crop season consecutively and in both crop seasons consecutively. The experimental materials reached to yield trial in 1967. The preliminary data indicate that the plants or strains selected consecutively in the second crop season tended to be earlier in maturity

than other materials. The low temperature in the later stages of the second crop rice growth probably acted as the contributing factor to this sequence.

13. Study of Breeding for Early-maturing and High Yielding Rice Varieties

Employing bulk and pedigree methods, the hybrid material of one selected crosses was used in selecting early-maturing and high yielding strains. The selected strains reached to primary yield trial this year (1967).

14. Influence of Seedlings Age to Grain Yield of Indica Rice Varieties

Three indica varieties were tested in 5 different seedling ages (30, 40, 50, 60 and 70 days in the first crop and 15, 25, 35, 45 and 55 days in the second crop). The yield difference among different seedling ages was not significant in the first crop season, but significant in the second crop season. In the second crop season, the younger the age, the higher was the yield. The contributing yield component was tillering number. The interaction between varieties and seedlings age was highly significant in both seasons.

15. Influence of Spacing to Grain Yield of Indica Rice Varieties

Three indica varieties were tested in four different spacings. The spacing, 27× 9cm, was found to yield highest. A tendency, the closer the spacing the higher the yield, was found.

16. Effects of Tordon Herbicide on the Yield of Rice and Weeds Control in Paddy Field

The effects of Tordon 22, which contains 22% of Tordon in the form of aqueous solution,on the growth yield of rice and weeds control in the paddy field were studied in the experimental farm of Taiwan Agricultural Research Institute.

Spray of Tordon 22 under drained condition, a few herbaceous weeds such as Monochoria Vaginalis PRESL and Rotala rotundifolia KOEHNE were killed, but most of other weeds remain unchanged in all treatments. 10-20% reduction in grain yield of rice was seen in treated plot 2,000cc/ha. Leaf color, heading date, number of tillers and plant of treated ones were greatly affected. The degree of plant injury is in parallel with the dose of Tordon 22 applied.

From the results mentioned above, it is concluded that Tordon 22 herbicide caused the severe injuries to rice plants by its toxicity but not very effective to all weeds in paddy field. It is then considered to be not good for practical application as a herbicide in the paddy field.

17. Comparative Studies on the Effect of Selection in Hybrid Population of Rice under Different Fertilizer Levels

In order to evaluate the effect of selection under different fertilizer levels in the hybrid populations of rice, two crosses i. e. Chianung No.242 × Colusa and Hsinchu No.56 × Indissol Dinoj were used for this study. The F_2 seeds were bulked and divided into two portions and were planted in ordinary and heavy fertilization plots respectively. The plants selected in the successive generations until F_5. From F_6 selections were made from two treatments on an individual plant basis. In F_7, 16 lines were selected from each treatment. In F_8, these lines were planted in the ordi-

nary fertilizer (N80), moderate fertilizer (N120) and heavy fertilizer (N160) plots.

In heavily fertilized plot, F_6 selections from the treatment of ordinary fertilization showed more panicle per hill than that from the treatment of heavily fertilization. The same tendency was found in F_7. Since no significant difference in panicle length was found between the two treatments, less panicle weight may be due to insufficient grain filling.

In ordinarily fertilized plot yield of the lines which selected previously under less fertilized condition was higher than those selected under heavily fertilized condition. In the moderately fertilized plot, no significant difference in yields between lines which selected under high and low fertilizer conditions was found. In the heavily fertilized plot, those lines which selected previously under heavy fertilizer condition got the higher yield. The difference in yield between lines of the two groups was statistically significant. These results showed that selection for lines of high nitrogen response under heavy fertilizer condition was effective.

In general, under heavy fertilizer condition, the sterile and half filledgrains would be increased. Therefore, special attention must be paid on this problem in developing a variety with high nitrogen response.

18. Comparative Study of Weed Control Methods in Rice

In wet season of 1964, the International Rice Research Institute initiated a research program to evaluate new chemicals and chemical combinations for weed control in rice at Chiayi, in cooperation with the Chiayi Agricultural Experiment Station. Some findings of this investigation are summarized as follows:

Ametryne and Simetrne gave best control of weeds, particularly to aquatic floating broad leaves. Large weeds were not controlled by PCP, MCPA, and 2, 4-D. Propanil gave poor control of weeds under the conditions of this experiment.

Rice plants were severely injured by Ametryne, PCP, and Simetryne. MCPCA was also found to have certain inhibitory effects on the growth of rice. Propanil and Swep were not toxic to rice under flooded condition.

Weeds hastened the heading of rice while chemical injury delayed it. Plant height and tillering ability of rice was significantly reduced at the early stage of growth. Panicle length and grain weight were not affected by herbicide treatments but weeds seemed to reduce number of grains per panicle.

DBN, MCPCA, PCP, Swep, Simetryne, Hydram and a mixture of Swep+MCPA produced more grain yields than weeded check. Weedy check reduced grain yield by 19.3% when compared with weeded one. Ametryne gave the lowest yield due to the reduction of stands caused by its toxicity to rice plant.

19. Effect of Growing Conditions on Grain Yield and Its Components in Rice

The effects of two rates of fertilization, three planting densities, and three shapes of planting on the growth of rice were evaluated in the second crop of 1963 and the first crop of 1964.

Grain yields increased with increasing fertilizers and planting densities. The increase of yields was more pronounced in the first crop of rice. Differences in yields

between fertilizer rates as well as among planting densities were not significant except in planting density of the first crop of 1964. Square shape of planting outyielded the other two rectangular shapes.

Number of panicles per hill slightly increased with added fertilizers, decreased significantly with increasing planting densities and remain almost the same among planting shapes. Number of grains per panicle decreased slightly with added fertilizers, decreased significantly with increasing densities. Rectangular shape with row space of 27 cm significantly increased grains per panicle in the second crop. Seed weight was least affected by the treatments.

Seed weight was significantly correlated with grain yield in the second crop for fertilizer rates, planting densities, square shape, and rectangular shape 2 (row space 27 cm). Grain number per panicle was significantly associated with grain yield in the first crop for fertilizer rates, high planting density, and square shape of planting. Panicle number per hill was significantly correlated with grain yield in the second crop for high planting density (96 hills/3.3m^2) and in the first crop for low planting density. Coefficients of determination showed that about 10 to 32% of seed yield variations could be ascribed to the effects of yield components.

20. A Study on the Natural Region for Rice Breeding in Taiwan

First crop season– It may be divided into two regions: Region "A" including Taipei, Taichung, and Chiayi areas. There were no significant differences on rice yield in the regional test of grain yield among three varietal groups (Taipei, Taichung and Chiayi) cultivated in three localities (Taipei, Taichung and Chiayi Stations). Region "B" including Chiayi and Pintung areas. Varieties developed from Chiayi may adapt well to Pintung. They can give a higher yielding capacity than the other 3 varietal groups, and showing signifficant differences. Therefore, Chiayi may be considered as the provincial rice breeding center of the first rice crop season.

Second crop season– It may also be divided into two regions: Region "A" is consists of Taipei and Taichung areas. Results showed that varieties bred in Taichung adapted well in the weather conditions of second rice crop in Taipei area. Region "B" Chiayi and Pintung areas. Comparing between these two (Chiayi & Pintung) varietal groups, their capacity of grain yield was identical, but varieties from Chiayi are more resistant to blast disease and varieties from Pintung are more resistant to new virus disease than the others during the second crop season.

Thus in the second rice crop season, Taichung may be chosen as the rice breeding center for the northern and central Taiwan. However, Pintung and Chiayi may be considered as the two rice breeding centers for southern Taiwan during the second crop.

B. Sweet Potato

1. Researches on Basic Problems of Sweet Potato

(1) *Study of Selfing and Hybrid Sterility on Sweet Potato*

Since 1959, we have carried out many studies on the selfing and hybrid sterility on sweet potato. From the results, we found that self incompatibility occurred

in most of the varieties, only few varieties that self fertility reached 30% and more. But we also found that at least five groups of hybrid sterility were existed among all the varieties. We can not obtain the hybrid seeds from the varieties belonging to the same hybrid sterility group. We can only get the hybrid seeds from the crosses of different hybrid sterility group. We have resolved and avoided a lot of difficulties and unnecessary lost in cross breeding Program.

(2) *Correlations between the Yield Components of Sweet Potato*

In accordance with the effective selection work in hybrid progenies, correlations and path coefficients were used to elucidate the relative importance of those characters of the parts above the ground level on weight of tuber, mean weight of tuber and number of tubers during the period of 1963–1964. We found that the most important characters among the yield components on sweet potato were number of tubers and weight of tuber. However, the weight of tuber and mean weight of tuber were mainly affected by the weight of vines, length of internode and number of internodes; but the number of tubers was affected directly or indirectly by weight of vines, length of internode and number of branches.

Other fundamental researches were also undertaken in the period of 1957–1961 The appropriate and effective design had been set out for research workers and farmers.

2. Varietal Improvement of Sweet Potato

(1) *The Collection and Characteristics Observation of Taiwan Native Varieties*

In order to obtain the varieties adapted to winter cultivation, early maturity, high yielding capacity, good quality and insensitive to weather, there are more than 100 promising native varieties have been collected and set under careful characteristic observation in 1964–1965.

The results showed that there were 15 varieties had 30,000–46,000 kg/ha of tuber yield, 7 varieties gave the chip percentage over 35% and 3 varieties yielded 30,000 kg/ha of fresh vines, A variety possessed a certain good character could be selected out from those varieties as an adapting ratoon and intercropping cultivation material.

(2) *Breeding for Starch/Carotene Rich, High Yielding and Early Maturity Varieties Through Hybridization and Selection*

Hybridization as well as polycross method has been conducted in the sweet potato improvement program. A type of reccurent selection is also to be carried out for accumulating favorable gene and increasing inter and intra chromosomal recombination in the hybrid populations.

3. Experiments on Sweet Potato Cultivation

(1) *Study on the Fertilizer Application*

The experiment on the important effect of N, P, and K fertilizer amount on the tuber yield and the appropriate combination ratio of these 3 elements under different planting seasons was carried out in 1963–1964. The results obtained from the sweet potato producing area of the whole island in three years showed that tuber

yield was significantly affected by nitrogen and potassium, but only slightly affected by phosphores. The most effective combine ratios are 2:1:4; 2:1:2 or 1:1:2 as $N:P_2O_5:K_2O$.

(2) *Studies on Improved Cultural Method of Sweet Potato*

In order to understand the efficient way to increase the yield of unit area, the experiment on spacing was carried out. The results showed that the best spacing was 1m × 0.2m (row × plant). It gave about 21% more of tuber yield. On the other studies, they indicated that the seedling raised from seed potato is better than that of others.

This kind of seedling can give 18% higher yield. On the other words, it can give a total of 132% of gain as compared to others.

C. Soybeans

1. Studies on the Characteristics and Chromosome Numbers of Some Glycine Spp.

Seven wild species in the genus *Glycine* were studied. The qualitative characters involved pubescence type, color and flower color of the wild species studied were similar to that of the cultivated forms. On the other hand, the quantitative characters, such as flowering date, maturity and weight per 100 seeds, had significant variation either among the wild species or between the wild and cultivated species. The wild species of *G. falcata*, *G. clandestina* and *G. tomentosa*, had the same chromosome number, n=20. They should be diploid forms. *G. tabacina* and *G. tomentella* had n=40 chromosomes, should be tetraploid. The wild species of *G. javanica* had n=11 and n=22 chromosomes in the 14 strains studied. The *G. borianii* also had n=11 chromosomes.

2. Studies on the Method of Embryo Culture in the Cultivated and Wild form Soybeans

Immature embryos of the species of cultivated soybeans (*Glycine max*) and wild form soybeans (including *G. ussuriensis*, *G. javancia* and *G. max* × *G. ussuriensis*) were cultured. White's basic medium and the one designated as D by the auther, were both effective for the germination of the immature embryos studied. The germinative date of the cultured embryos was 9–10 days after anthesis in the species of *G. max*, and 15–20 days in the species of *G. ussuriensis*, *G. javanica*, and *G. max* × *G. ussuriensis*. Transference of the seedlings from the medium into soil or first into sand which watered with a nutrient solution, and then into soil, both proved to be successful.

3. The Breeding of Rust Resistance Soybean Variety "Tainung 3"

"Tainung 3" soybean (*Clycine max* (L.) *merr.*) was selected from F_7 plants of the cross (Nung-shih H-11 × PI 200492) in 1963. Prior to release, Tainung 3 was indentified by the number Nung-shih 63-11. It is adapted to the whole island in the spring and winter crop.

Tainung 3 is characterized by purple flowers, brown pubescence, large size (weight per 100 seeds, 18–20 grams), yellow seed coats and brown hila. Tainung 3 outyielded Tai-ta-Kaohsiung 5, which is a leading commercial variety in Taiwan, 17–

52% in the winter crop and 15-178% in the spring crop. It has similar maturity with Tai-ta-Kaohsiung 5. Tainung 3 is resistant to lodging and to soybean rust (phokospsora pachythizi, Saw.) that showed leaves wilting at the early infection, and defoliation at later stages. The only one undesirable character is the cracking of seed coat.

Tainung 3 was named in December 1967, and will be released from 1968.

D. Peanuts

1. Studies on the Genetic Behavior of Quantitative Characters in the Hybrid Progenies of Virginia and Spanish Peanut

The purpose of this experiment is to study the genetic behavior of six quantitative characters in the hybrid progenies of Spanish type × Virginia type. The parents Tainung No. 1(Spanish type), Florispan runner (Virgina type), F_2 an F_3 were used in this study.

The significant hybrid vigor for length of main stem and length of branches in segregating populations was observed, especially in the F_2 generation. It was found that the days to flowering in segregating generation was less than that of their parented and tended toward the Virginia type parent. The mean values obtained from the other characters, as number of branches, number of pods and weight of pods were similar to those of mid-parent values, respectively.

The genetic variances for days to flowering(additive effect) and number of branches (dominant effect) were greater than environmental varience. But the magnitude of environmental variance and genetic variance were almost equal in the characters of number of pods per plant, weight of pods per plants, length of branch and length of main stem. However, the genetic variance is principally dominance variance for number of pods and weight of pods, moreover, which is mostly additive genetic effect for the Iength of main stem, and the length of branch.

The heritability values obtained from several formulas for days to flowering were high, while those for number of pods and weight of pods per plant were relatively small, the heritabilities for length of main stem, number of branches, and length of branch estimated from different formulas were variable.

Significant correlations were found between number of pods and weight of pods. The positive relationships were found between the number of branches, length of branch, and length of main stem to the number of pods and weight of pods. However, negative correlations were obtained between days to flowering and number of pods or weight of pods per plant.

2. Heritability of Hybrid Progeneies of Spanish and Virginia Peanut

A total number of eight cross-combinations involving two Spanish and four Virginia type varieties of peanut were used to estimate the heritability of several main characteristics.

The result obtained from this preliminary study can be cummarized as follows:

(1) With one or two exceptions, the heritability of weight of fresh plant number of leaflet and degree of bending of branch is high as 50%.

(2) The heritability of height of main stem and length of branch is lower than 40%. However, it varied under the conditions of different spacings.

(3) The heritability of number of branch and position of terminal pod varied from different cross combinations. It might be due to the difference among parental varieties.

(4) The heritability of stem diameter, number of pod and weight of pod was below 40%, and differed from different cross- combinations.

3. The Analysis of Path Coefficient of Yield Components in Different Types of Peanut

For studying the inter-relationships between yield component characters to the yield of peanuts, 173 varieties of peanut including 38 Virginia Runner, 35 Virginia Bunch and 100 Spanish were collected for field trials. The results are summerized as follows:

Significant differences were found among plant characters in various types of peanut. In general, the Virginia Runner type has relatively shorter main stem, the longer and more branches, the more leaflet and higher position of terminal pod than those of Spanish type. Those of Virginia Bunch type were in between the other two types. Significant positive correlations were observed among 5 pairs of the plant characters, others were negatively correlated, and still others were different in different types of peanuts.

After all, the similar results were also obtained in the Virginia Bunch type. But the correlation between the number of pod and average weight per pod was small but positive. Therefore, the net effect of these two characters on yield would be cumulative. In the Spanish type, the yield of pod was more directly affected by the number of pod rather than by the average weight per pod. Further, the slightly negative indirect effect of the average weight per pod on yield was also obtained. It is apparent that the yield of the Spanish type was more affected by the number of pod than by the average weight per pod.

4. The Path Coefficient of Yield Components of Peanut Growing in Different Seasons

To study the inter-relationship of characters of yield components to the yield of peanut grown in different seasons, 30 varieties of peanut considered as erect type and early maturity were used in the field trials which were conducted in Spring and Fall, 1966. From the varied results of inter-relationships between these characters which belong to the important yield components, the results indicated as follows:

The length of main stem and the number of branches had favorable effect on Spring crop but unfavorable on Fall crop. It is due to the fact that the flowering period is shorter in the Fall, the branches emerged in the later stage had nothing to do with the formation of pod. The length of internode had harmful effect on both Spring and Fall crops. It showed that the length of internode would reduce the number of flowering and cause the tubing of ovary not easy to penetrate into the soil for pod formation.

The length of internode would reduce the number of pod per plant but increase

the weight of single pod. The number of branches had favorable effect on the yield of pod in both Spring and Fall crop, it was especially true in the case of Spring crop. On the contrary, the length of internode had harmful effect on the yield of pod. It was interested to note that the effect of the length of main stem on the yield of pod was favorable for Spring crop, but not for Fall crop.

In Spring crop, the number of pod per plant and the percentage of hulled pod had much to do with the yield of pod. The relationship between the weight of single pod (or size of pod) and the yield of pod was uncertain. In Fall crop, the number of pod per plant and weight of single pod had favorable effect on the yield of pod, but the percentage of hulled pod had nothing to do with yield. It, in some cases, may cause harmful effect.

E. Essential Oil Crops

Citronella grass is one of the important economic crops in Taiwan. Since 1961, an extensive studies have been initiated to improve the current cultural practices which was considered to be relatively rough one. Three experiments were carried out for this purpose:

1. *The Effects of Mulch and Fertilization on the Yield of Grass, Oil Content and Oil Quality of Citronella Grass*

It was found that the yield of fresh grass and oil content in each treatment varied from years, seasons and places. In general, the grass yield of the two fertilized treatments, whether mulched or not, was greater than that of the two unfertilized treatments throughout the whole experiments. But the effect of mulch differed in each year. On the other hand, percentage of oil content was slightly affected, at least in this experiment, by mulch and/or fertilization. Therefore, high grass yield resulted in high oil content. The quality of the citronella oil collected from all the treatments in 1962 gave similar result. The treatment subjected to mulch and nonfertilization yielded a higher content of citronella oil content (60% above) than those of other treatments (ca. 40%). But the result was different in the following year.

2. *The Effect of Fertilization on Citronella Grass*

In order to test the effect of three essential elements on the grass yield and oil content of citronella grass, the experiment was carried out in 1963. The results indicated that the grass yield was significantly increased by the application of nitrogen fertilizer in most instances. Moreover, when P and K were applied with N, a notable increase of the grass yield was observed in many cases. Generally, percentage of oil content seemed to be decreased with increased amount of N. But, it was slightly increased by P and K.

3. *Spacing Experiment on Citronella Grass*

The effect of spacing indicated in this experiment was significant. The grass yields of five treatments were in the order of treatment D (100cm×30cm), A (70cm×70cm), C (100cm×50cm), E (120cm×50cm) and B (100cm×100cm). However, yield differences among C, E and B were not statistically significant.

The percent of oil content affected by different spacing was small. But the citronella oil content was slightly affected by spacing.

F. Green Manure

1. *The Effect of Astragalus Sinicus on the Growth of Rice on a Poorly Drained Soil*

A field test was conducted on a poorly drained slate alluvial soil at Tungshan, Ilan with the purpose to study the effect of fresh green manure on yield of rice under long submerged soil conditions. The field experiment was laid out in a split plot design. There are two main treatments, namely, (1) Soil ploughed up and redged after the harvest of the previous crop of rice until the transplanting of next rice crop and (2) soil was kept submerged after the harvest of the second crop of rice until the transplanting of the next crop of rice Each main treatment was further subdivided into three fertilizer sub-treatments as follows:

(1) N-P_2O_5-K_2O at the rate of 80-60-0 Kg/ha.
(2) N-P_2O_5-K_2O at the rate of 80-60-100 Kg/ha.
(3) N-P_2O_5-K_2O at the rate of 40-60-100 Kg/ha, and 10,000 Kg/ha.

The green manure in the form of fresh *Astragalus sinicus* vines was applied on March 19, 1963. Chemical fertilizers were dressed on March 23, 1963. In each subplot, five varieties, Ya-lun, Bir-mie-fen, Tainan No. 3, Chianung No. 242, Taipei No. 306. each in four rows, were randomly planted. The results of the experiment are as follows:

(1) Plowing-up and ridging of the soil for sufficient aeration and oxidation greatly favors the yield of rice as compared with the submerged soil.
(2) Heavy rate of fresh green manure under long-submerged soil condition seriously induced suffocation desease of rice due to possibly the toxic substances produced in course of the anaerobic decompostion.
(3) Potassium can apparently alleviate the seriousness of the physiological disorder, and hence increase the yield of rice. Among the five varieties, the two indicas are more tolerent to the low redox potential of the poorly drained soil than the three Japonicas.

2. *Demonstration of Astragalus Sinicus as a Winter Green Manure in Paddy Field*

For the purpose to demonstrate the *A. sinicus* as a winter green manure in paddy field, trials were conducted simulataneously at nine prefectures. The number of demonstration-plots was seventy one in total. The area for each demonstration plot is five acre ($20\times25=500m^2$), in which one-half is used to produce seeds. A total amount of 750 grams seeds mixed with 15 kilograms of soils that formerly *A. sinicus* was planted once, was drilled in rows at the interval of two rice plant rows before 15-20 days of the second rice crop harvesting.

The yield of green materials was obviously related with the soil texture and pH value. Results obtained from the soil analysis indicated that the green materials increased the pH value. Meanwhile, the weight of green materials was also higher in loam than in that of clay soils. The highest amount of green materials as well as the average yield produced in each prefecture can be summarized as follows:

Prefecture	The highest yields(kg.)	The average yield(kg.)
Ilan	36,900	22,684
Taipei	32,250	22,606
Taoyuan	29,250	22,044
Hsinchu	38,750	29,173
Miaoli	34,125	26,425
Taichung	28,000	24,250
Changhwa	24,000	17,500
Hwalien	45,380	35,939
Taitung	25,000 (only one demonstration plot)	

Seeds produced in each demonstration-plot were varied from different prefectures, as the average of 50 Kg/ha in Ilan up to 500 Kg/ha in Hsinchu, because of the different weather conditions.

3. Studies on the Suitable Planting of Astragalus Sinicus as a Winter Paddy Green Manure and its Influences to the Succeeding Crop of Rice

This experiment was conducted simultaneously at five localitites namely Taipei, Hsinchuang, Ilan, Taoyuan and Hsinchu. A 4×4 Latin-square design with four replications was adopted in this experiment. The time of sowing of milk vetch started from the later October to the early December according to the suitable crop season at each locality. At the time of sowing as well as the growing period of milk vetch, there were no fertilizers applied. Up to the succeeding year, the milk vetch was ploughed into soil as green manure at the time of two weeks before the transplanting of the first rice crop. Before transplanting, 400 grams of calcium superphosphate and 250 grams of potassium sulphate were together applied in each plot as basic dressing. The amount of milk vetch which ploughed into soils was limited in 50 kilograms for each plot. After transplanting of rice, 125 grams of ammonia sulphate was applied as top dresing in each plot during the second weeding.

The uniformity and velocity of germinations of milk vetch in various locations appeared in vigor and normal. The duration from sowing to initiate flowering was about 100 to 110 days. Among various treatments, the interplanting of 15 days before rice harvesting gave the highest yield of green materials with no exception in five experimental locations. For different locations, Hsinchu produced 25,120 kilograms of green material per hectare and Taipei ranked second as produced 23,425 kilograms. Ilan, Taoyuan and Hsinchuang localities, because of the defect of drainage and over acidity of soils, were poor in growth of milk vetch and produced very low amount of green materials.

The yield of succeeding crop of rice was also higher in the plot of interplanting

treatment of milk vetch. The check plots which no milk vetch planted gave the lowest yield among all treatments. The analysis of variance of rough rice was higher significant in Taipei location but not in other four places. The yield of check plot was significantly lower than the three treatments which milk vetch planted. There was, however, no significant differences can be seen between the treatment of interplanting and other two treatments.

G. Cotton

Researches on cotton crop have been carried out at the Tainan Fiber Crops Experiment Station. Taiwan is not suitable for the cultivation of cotton owing to the handicaps of typhoons and insect pests. The acreage of cotton in Taiwan was formerly limited to several hundreds hectares. Fortunately, these handicaps have been overcome in 3 aspects; achievement in acclimatization of good upland-cotton varieties, control of pests, and intensive cultivation. The result of demonstrations conducted in Taiwan and Kinmen Island in 1958 showed that the average seed cotton yield was 1389 kg/ha., which is 4.5 times the yield of former time (300 kg/ha.) The acreage increased from 2165 ha. in 1952 to the level of 5320 ha. in 1960. The cotton fields in the past were limited to the Chianan Plain and Taitung county, but now they have been gradually extended to other 9 counties: Pingtung, Kaohsiung, Changhua, Taichung, Miaoli, Nantou, Hsinchu, Taoyuang, and Hualien. The main effects of cotton improvement are summarized as follows:

1. Acclimatization of New Cotton Varieties

(1) More than two hundred varieties of cotton have been introduced from abroad. These varieties are of three types: upland cotton (including long staple and medium staple), Egyptian cotton, and Indian cotton. Thirteen sets of varietal tests have been conducted for comparing yielding ability and qualities of these introduced varieties. The results of these tests revealed that most of the varieties can adapt themselves to the environment of Taiwan. Two main varieties, Stoneville and Delfos which grew well on the mainland, have been found to have maintained their merits in Taiwan.

Empire, Rex, and Austin are the most promising varieties of medium staple upland cotton. They have been extended to the cotton growers in the past ten years.

Stoneville 7-54206, Earlistaple 7-1, and lls-7a are the most promising varieties of long staple upland cotton. The merits of "Stoneville 7-54206" are described as follows:

(a) Data from varietal observation (1961):—The yield of Stoneville 7-54206 was the highest among 35 varieties tested.

Seed cotton yield (kg/ha.)	Lint%	Staple length (mm.)	Seed index	Capsules/lb
2682	37.1	31.0	11.0	77.0

(b) Data from varietal test (1962-1964):—The yield of Stoneville 7-54206 was the highest among 10 varieties:

Variety	Lint Yield (kg/ha)					Staple Length (m.m.)	Lint %
	1962	1963	1964	Ave.	Index%		
Stoneville 7–54206	938	1050	645	878	129	32.5	35.9
11s–7a	791	1056	596	814	119	32.9	30.0
Rex Smooth Leaf	711	971	749	810	119	30.6	34.9
6s 2/5	798	860	438	699	102	32.6	32.8
Empire	691	919	440	683	100	31.1	32.8
Coker Wild's	680	891	466	679	99	33.3	32.1
Texacala Original	704	778	413	632	93	32.1	34.8
Coast land RN	220	723	423	455	67	34.4	33.4
Messilla Valley Acala	579	823	360	587	86	33.0	32.5
Menoufi 6aa	—	341	159	250	37	35.0	32.4
L.S.D. 5%	91.16	88.77	93.06	73.95			
L.S.D. 1%	121.76	118.57	124.30	104.04			

(c) Data from regional test (1964–1966):—The yield of Stoneville 7–54206 was the highest among 9 varieties:

Variety	Lint Yield (kg/ha.)					Index %
	Taishi	Lochou	Choucher	Zian	Ave.	
Rex (ck)	771	816	862	624	768	100.0
Stoneville 508A	811	942	812	644	802	104.4
Stoneville 7–54206	859	996	891	631	866	112.8
Stoneville 426	851	978	876	650	839	109.2
6s 2/5	688	838	697	619	711	92.6
11s–7a	748	920	840	562	768	100.0
Coker Wild	704	819	749	517	697	90.8
Sealand 542	614	742	639	439	609	79.3
Earlistaple 7–1	644	714	646	513	629	87.9

(2) Some promising varieties of Indian arboreum cotton were also selected. 35/1 and Rosea 231 are the most promising varieties expected to be released for the production of raw cotton which is used for making quilt and for spinning yarn below 16 counts.

(3) Both the long staple upland cotton varieties and the medium staple upland cotton varieties have undergone regional tests. The regional tests of upland cotton in the past 15 years can be divided into 5 steps. Every step consists of 4–9 varieties and 4–5 districts. Empire and Stoneville 7–54206 are two outstanding varieties which

have high yielding ability, excellent quality, and wide adaptability.

2. *Pedigreed Pure–line Breeding*

Tainan Station spent 11 years in making pedigreed pure–line selection for upland cotton. From 1955 to 1959, a very excellent strain N–35 was obtained. Its yielding ability was high, but the lint percentage was only 28.1%, lower than that of Austin which was introduced from abroad in comparison test. Another strain, Y–14, was obtained in pedigreed pure–line selection, but the difference between Y–14 and the check variety was insignificant statistically. Hence this strain was not put into comparison test with other varieties.

In the pure–line selection of Indian arboreum cotton, six strains were selected. Among them, No.26 has the highest yielding ability and highest lint percentage. It belongs to the verum type of arboreum cotton. No. 57 matures very early and belongs to the rosea type. No.30 has small boll but longer staple, and it may belong to the Indicum race. Besides the strains in pure–line selection, there is another strain of arboreum cotton, No.5. It is used as a common variety of arboreum cotton. Probably it belongs to the verum type.

3. *Hybridization Breeding*

Cross–breeding work has been done since 1958. Among the progenies segregated after crossing upland cotton, strains were selected in breeding tests made during 1961–1962 for the purpose of seeking out prolific and vigorous ones with long staple. Among 24 strains, No.35 is the best one.

Cross–breeding is a basic method in the improvement of cotton, because the varieties introduced from abroad will degenerate rapidly in the environment of Taiwan. Hence Tainan Station will continue to carry out cross–breeding of cotton in the future.

4. *Improvement of Cotton Cultivation*

(1) *Determination of Appropriate Planting Season*

The optimum sowing time of upland cotton is in June, in order to minimize typhoon damage and to obtain the highest production in southwestern Taiwan, with the exception of the west coast.

(2) *Fertilizer Requirement*

The optimum amount of fertilizers per hectare in Tainan is N–150 kg, P_2O_5–80 kg, K_2O–150 kg. However, from the standpoint of economical return, the amount recommended is N–80 kg, P_2O_5–60 kg, K_2O–100 kg.

(3) *Planting Space in Cotton Cultivation*

For simple crop of upland cotton, the planting space 90 cm×40cm is recommended.

(4) *Intercropping Cotton with Other Crops*

(a) Cotton can be planted between peanut rows before the harvest of the first crop of peanut. The growing season of peanut is from March to July, while that of cotton is from June to December. It is recommended that peanut ought to be planted densely. The narrower the distance between hills, the higher the yield of peanut will be.

(b) Sugar-cane can be interplanted with cotton. The yield of seed cotton may be as high as 2000 kg/ha. Although it is slightly affected by wide spacing, the yield of sugar-cane is reduced by 2-7% only. Planting space may be reduced between hills, so as to compensate for the loss due to wide spacing. Hence this interplanting system has the effect of increasing the farmer's income. Cotton may be interplanted with sugar-cane in alternate rows. The former is sown from June to early July, and the use of the variety Austin is recommended. The number of stalks and yield of sugar-cane interplanted can be increased by better irrigation and fertilization, and by defoliating cotton with calcium cyanamide 40 kg/ha. 130 days after cotton germination.

H. Flax

1. Pollen Dissemination Study on Flax

Survey of pollen dissemination of flax was made by exposing slides in air under natural conditions to determine the distance or range of dispersion in Taipei. The information is valuable for the prevention of possible natural crossings and thus keeping the purity of flax varieties. It has been found that the flax pollen with the aid of wind may disperse to a considerable distance. Wind therefore is an important factor in the dissemination of flax pollen. It has been suggested that the beds for keeping the stock plants of flax varieties be so placed as to run parallel to the direction of prevailing winds in order to reduce the chances of natural crossing. The dissemination of pollen was, to a certain extent, also influenced by other climatic facors, and flax shed more pollen beforenoon than afternoon.

2. Studies on the Development of Flax Fiber

Planting of two varieties of flax, Pernau and Irland, was done at 10-day intervals, from October 11 to December 20, 1946 in Taipei. After germination and a growth period of 10 days, samples were taken from the plants, and this was repeated at 10-day intervals until harvest. A series of investigations on their growth performance and on the histological sections of the samples were made. Results indicated that the 10-day old plants were too young to form fiber cells. The formation of fiber cells was not conspicuous even in plants 20-30 days after germination, and the development of fiber cells and fiber bundles did not start and increase until 40 days after germination. At the later stage of plant growth, the increase in fiber cells was small and the fiber bundles even tend to decrease in number due to the coalescence of neighboring ones. The fiber cells were fully developed about one month after blooming. There was a significant increase in the number of fiber cells for plants sown in December, which resulted in a higher yield of stem and fiber content. No significant differences in the distribution of fiber cells could be found among the plants of different planting dates. Fiber cells were most abundant on the stems 20-40 cm. above the cotyledonary scars; and their shape, size and arrangement of the fiber bundles were also uniform and compactly distributed. This part may be considered as the best portion of flax stem, so far as the source of flax fibers of high quality is concerned. Fiber cells below the cotyledonary scars were usually irregular in size, with large lumens, and coarser fiber

bundles; and those at the top portion of the stem were usually immature, irregular in form and thin walled.

3. Photoperiodism of Flax Varieties

In 1946, four flax varieties sown at different times and given different lengths of illumination to represent different sets of temperature, humidity and photoperiod, were studied in Taipei to find out their responses in connection with maturity. It was found that the blooming of flax was delayed or the period of vegetative growth prolonged when treated with shorter day-length; and the result was to the contrary when treated with longer day-length. Such phenomenon was more pronounced in varieties with a longer period of growth. Temperature affected both types of varieties but the effect was more pronounced in the latter case. In other words, late-maturing varieties responded to a considerable degree to both light and temperature, while early-maturing varieties responded to a lesser degree to light than to temperature. (For more details see Annual Report of 1948)

4. Spinning Test of Flax Fibers

The study was continued for a period of three years in Taipei. From June to September 1949, tests were made on the 15th day of each month. Four different treatments, i.e., spinning after dipping flax fibers in water for 2,3,4, and 5 days (dipping for 1 day or more than 6 days was discarded due to poor results obtained in the previous year) were applied. Comparisons of fiber qualities between the years demonstrated the sensitivity of flax varieties to soil and climate. It was found from the results of the comparisons that the percentage of spinnable fibers decreased with the increase in number of days of dipping in water. The percentage of spinnable fibers was higher when dipped for 2 days, but the fibers were somewhat more coarse and harsh with a yellowish color and luster. When dipped for 3 days, the percentage of spinnable fibers was slightly lower, but the fibers were more pliable with a brighter color and luster. No advantages were observed in dippings for 4 days or longer, and dipping for 2-3 days was recommended.

5. Natural Crossing Percentage of Flax

Results of this study showed that the closer the space between rows, the higher would be the percentage or natural crossing as indicated by the following figures:

Variety: Tsing Kowh

Treatment:

Row spacing cm	30	45	60	90	120
Natural crossing%	1.66	1.37	0.62	0.33	0.25

6. Improvement of Flax Varieties

In order to produce new flax varieties high in both fiber and seed yields, three new varieties, i.e., Taichung Selection No.1,2-127, and 2-192, have been selected from the progenies obtained through hybridization. All of these new varieties or strains are early maturing and are highly productive in seed and fiber. Their average growing periods are 110, 107 and 125 days respectively. Such characteristics are desirable for

fitting in the time gap between two rice crops. Taichung Selection No.1 has been an extension variety for more than 15 years. In 1960, a set of the world collection of both fiber and seed-flax varieties was introduced from USDA to Taiwan for observation and trial. A flax improvement program was started in the same year. After obervations and tests, a promising variety, C.I. 1799, has been selected since 1966 for trial planting in Taichung and Changhua. Its straw yield is 31.5% more than the check variety, Taichung Selection No.1, its seed yield is almost the same as the latter, and its growing period is about one week later than the latter.

7. Improvement of Flax Cultivation

From 1956 to 1958, an experiment on the sowing date was carried out with four seed-flax varieties as testing materials. The results show that the middle of November is the optimum time of sowing for seed production. The proper time of broadcasting is around November 20th of each year at the seeding rate of 70 kg/ha. The appropriate sowing rate in drill planting with 15 cm. for various varieties of seed flax is 1200 plants/m^2, as shown in the experiments made from 1961 to 1964. Regardless of whether the purpose is to cultivate flax for seed or fiber, the sowing rate must be determined by its germination rate and seed size.

The optimum amount of fertilizer for flax is 30 kg. of N, 30 kg. of P_2O_5, and 75kg. of K_2O per hectare.

In the case of the variety now under extension, harvesting is done 90–100 days after sowing.

For improving the quality of flax fiber, land preparation must be carefully carried out before sowing. The weeds can be controlled effectively by a weed killer, Karmex. The dosage of Karmex is 500 gm. per hectare. The solution of 0.05% concentration can be sprayed when the seedlings are 5 cm. to 10 cm. in height.

I. Ramie

1. Improvement of Ramie Varieties

In Taiwan, ramie is cultivated mostly on upland hillsides or in slope areas. Varieties which would be adaptable in such areas must be resistant to drought, frost, and diseases, and also high yielding. The main improvement work on ramie can be summarized as follows:

(1) *Introduction and Selection*

Since 1947, more than one hundred varieties have been collected from domestic sources and foreign countries including Japan, France, the U.S.A. and the Philippines. Through continued studies, a number of good varieties such as "Miyazaki No. 112" and "Steel Wire No.3" have been selected. The yields of crude fiber of these selections are higher than that of the local variety "Nanhua Green Skin" by 7–11%. In recent years, Kawaminami No.2, Green Slender, White Skin, and P.I. 87521 have also been introduced from Japan and the U.S.A.

(2) *The Preliminary Study of Ramie Breedings*

In order to compare the selected progenies from intercrosses between strains and varieties, 52 lines were selected in the first year. Among the progenies of four

intercrosses, 20 lines were selected after the plant-row observation test in the second year. After all, 12 lines were remained as the promising strains. Among them, 8 strains out of 12 lines were derivatives of TP 60c 71 cross, indicating that the parents of this cross possesed good quality. However, none of the natural crossed progenies was among the 12 lines.

The highest yield of fiber (dry weight) obtained in the study is produced by TP 60c 71–69 that the index is 215% as compared to control variety. Therefore, through a proper selection procedure, a line which posseses the higher yielding capacity than the original variety can be obtained.

The 12 selected lines will be undertaken for other studies.

(3) *Breeding Through Mutation Induced by Colchicine and Radiation*

Colchicine has been used to treat ramie seeds for inducing mutation. 52 plants were selected from the offsprings developed from seeds treated with colchicine. Some of them were found to be growing vigorously and producing more tillers. Cytological studies to check whether these had been actually induced by colchicine were performed. With regard to fiber yields, the mutant tetraploid is 23.1% higher than diploid. The fiber yield of mutant tetraploid Mc–60–2 and Mc–60–11 are even a little higher than that of Kawaminami No.2 which was selected by hybridization in Japan. In order to induce mutation by irradiation, ramie seeds and suckers were treated in 1960 with X-ray of various degrees of intensity and various lengths of time. From the preliminary results obtained, it seems that the intensity of radiation below 50,000r is strong enough for treating ramie seed for inducing mutation. All the seedlings treated have been planted for observation and test.

(4) *Breeding through Selfing and Crossing*

Some good varieties have been selected for selfing since 1957. 56 selfed lines of the first generation, 7 lines of the second generation, and 105 lines of the third generation have been selected, and 18 excellent selfed lines of the third generation will be selected as materials for crossing among themselves and with good varieties. Besides, some male sterile plants were discovered in the selfed lines as breeding material.

(5) *Standardization of Breeding Procedures*

In 1960, a draft for the methods and procedures of breeding ramie was prepared. Copies of it have been circulated to the plant breeders in Taiwan for suggestions and revisions. It is expected that a revised set of standard procedures for ramie breeding will be formulated shortly.

2. Improvement of Ramie Cultivation

(1) *Method of Propagating Ramie Plant*

Experiments on the propagating methods of ramie have been conducted. Young ramie plants can be successfully propagated from seed, and the number of seedlings obtained is 3 times as many as that propagated asexually either from rhizomes or from root stocks. However, the speed of rhizome development from seedlings is slower than those from asexually propagated plants. Rhizome is still the popular

method used by farmers for propagating ramie.

(2) *Application of Fertilizer and Mulching of Ramie Plants with Straw*

According to experiments, 90kg. of N, 30 kg. of P_2O_5 and 90 kg. of K_2O gave the maximum fiber yield. However, for economical application, especially when compost manure is available, the rate of 120 kg. of N, 20 kg. of P_2O_5 and 60 kg. of K_2O is recommended. Green manure and chemical fertilizers are suitable for land on the slopes, while compost, nightsoil and chemical fertilizers are suitable for land on the plain. Mulching of plants with straw in winter will protect the crop from frost and will increase the yield of fibers.

3. Improvement of Fiber Processing

(1) *Irrigation of Ramie Field by Using Sprinkler in Dry Season*

From winter to the following spring in the central and southern parts of Taiwan, ramie grows slowly and can not be harvested due to the lack of irrigating water. By using sprinkler irrigation at 15-day intervals during the dry season, the number of harvests could be increased from 3 to 5. The yield of crude fiber from irrigated fields is uniformly increased by 70% over that from the field without irrigation.

(2) *Fumigation and Degumming of Ramie Fiber*

After decortication, the wet crude fiber should be fumigated as soon as possible before drying in a closed room with sulphur for 1 hour, in order to avoid molding and to keep the fiber white and lustrous. The chemical methods of degumming have also been studied.

4. The Influence of Photoperiodism on the Development of Fiber Cells in Ramie

Results of this experiment indicate that:

(1) The number of fiber bundles tended to be larger when growth of ramie was under the 8-hour than under the 16-hour treatment.

(2) The number of fiber bundles was the largest in the upper, lesser in the lower, and least in the middle portion of the stem.

(3) The distribution of fiber bundles was more uniform under the 16-hour treatment and also in the middle portion of the stem. Those fiber bundles in the lower portion of the stem were distributed next in uniformity, and those in the upper, the least in uniformity.

(4) It can be concluded that short day-length may promote the development of fiber cells while long day-length may have the contrary effect.

J. Jute and Its Substitutes

Kenaf (*Hibiscus cannabinus L.*) and roselle (Thai kenaf) (*Hibiscus sabdariffa L. var. altissima*) have been studied thoroughly in recent years as substitutes for jute in the gunny sack industry. Kenaf can be grown on upland. Roselle has been found to be fairly adaptable in Taiwan, particularly in places of dryland with good drainage. However, it did not do well in paddy field. Moreover, roselle was found very resistant to the attack of root-knot nematode which is prevalent on both jute and kenaf.

1. Improvement of Jute Varieties

(1) *Standardization of Jute Breeding Program*: Through repeated discussions and revisions by the plant breeders in Taiwan, a set of standard procedures for jute breeding was established and put into effect by the Tainan Fiber Crops Experiment Station from 1952 to 1953.

(2) *Introduction of Promising Varieties*: olimoes, a very insensitive variety which showed good results in low latitude areas of African countries, was introduced from the U.S.A. for trial planting. FS-61-I-2097, another promising variety with auxilliary buds, was introduced from India in 1961. Its yield surpassed that of Tainung No. 1 by 13.7% in regional test.

(3) *Selection of Promising Varieties from the Jute Breeding Program*: Tainung No. 1 with high yield and anthracnose resistance was picked for extension in 1962 after 10 years of pure line selection from 1952 to 1961. Tainung No.2, an insensitive and high yielding variety, was also selected for extension in 1967 through hybridization started in 1952. FS-50-pt-2, which was selected by hybridization in the central part of Taiwan, is resistant to anthracnose and produces 12.7% more of scratched fiber than the popular variety Taichung Special No. 1 during demonstrations from 1966 to 1967.

2. Improvement of Jute Cultivation

The steady increase of unit yield of jute in the past decade is due mainly to the improved variety and cultural practices. Mixing of jute seeds with Spergon (1:100) to prevent the damping-off disease has been adopted by all the jute farmers; the liberal application of compost (20,000 kg/ha.) in addition to chemical fertilizers (Ammonium sulphate 400 kg., fused phosphate 140 kg. and potassium chloride 120 kg. to each hectare), the repeated weeding and cultivations, etc. are all aimed at achieving increased yields and improved quality.

(1) *Transplanting of Jute*

Transplanting of jute seedlings has proved to be successful through years of experimentation. The practice is to raise jute seedlings in nursery where irrigation water is available. When the seedlings are 20 days old, they are ready for transplanting into the field.

In the central part of Taiwan, farm land is used very intensively. Several crops are grown in the year on a same piece of land either in succession or by relay-interplanting. To raise jute in the nursery for a period of 40-50 days and then transplant the seedlings into the paddy field under the condition of intercropping with rice for 15 days would save a total of 55-65 days of land use. Then, in early August, when the jute crop is harvested, the second rice crop can be planted. Through this practice, without affecting either of the two rice crops, an additional crop of jute may be sandwiched between them. This practice has been adopted by farmers in central Taiwan.

In southern Taiwan, the rainy season starts from April and ends in October. After that, dry season prevails. In recent years, the rainy season sometimes comes 20-30 days late, which makes it difficult to plant jute in time. If the farmer is to

wait until the rainy season starts, the yield of the crop would be affected. By resorting to this practice, jute seedlings could be raised in a small area of land with adequate water for irrigation. As soon as the rainy season arrives, jute seedlings can be transplanted into the field. Also in areas where the previous crop, like sweet potato, requires a longer period of growth to reach its maximum yield, the transplanting method is very useful as it will not affect the yield of the previous crop, nor that of jute.

(2) *Production of Jute Seed*

In order to increase the yield and meet the shortage of jute seed due to typhoon damage in Taiwan, the following methods for collecting jute seed have been studied.

(a) To sow jute seed in December in the southern parts of Taiwan where winter temperatures are comparatively mild and collect the seed in time (April) for normal fiber planting: During the growing period, chlorobenzilate should be applied in order to protect the young seedlings of jute from mite injury. Karathane and Triton should also be applied heavily to control the powdery mildew so as to enable the jute plant to grow normally. The amount of jute seeds obtained in this way was about 120 kg/ha.

Technically, the above practice could eliminate the loss of seed caused by typhoon. However, due to the lower seed yield and the need for heavy application of pesticides, the cost of production is rather high; therfore, its practicability has yet to be determined.

(b) Late sowing in June may result in short vegetative growth, low plant height, less damage and high seed production up to 600–800 kg./ha.

(c) Collection of seed from jute planted normally in April.

(i) Supply of additional amount of fertilizrs in the late growing period: The increase in the yield of jute seed by the additional application of 150 kg. of ammonium sulfate, 50 kg. of calcium superphosphate and 40 kg. of potassium chloride in the late growing period will be about 7%.

(ii) Binding of apical cutting:During harvest time, the apical portion may be cut off from the stalk as cuttings and bound on a piece of jute pith 8–10 cm. long with retted fiber. By inserting the jute pith into a flooded field as support, leaving the basal portion of the apical cutting immersed in water but above the soil, fibrous roots may develop within 5–8 days. If properly managed, the rate of survival may reach more than 90%. After the cutting is set, new flowers will evolve and capsules take form. The seeds will mature in 80–90 days. Since the apical cutting is only about 80–120 cm. high, typhoon damage may be reduced to the minimum. Furthermore, it can be conveniently used for crossing in breeding work.

(iii) The effect of irrigation and increased application of fertilizers during the growing stage of jute:

The average yield of retted fiber with irrigation available in the whole growing period is 2,514.5 kg/ha., and if irrigation is available only in the middle growing stage 30–60 days after germination, the yield is 2,475.5 kg/ha. They are, respectively, 22.7% and 20.8% higher than the yield obtained without any irrigation at all. It is necessary to irrigate in the middle growing stage in order to increase the yield of retted fiber effectively, no matter what amount of fertilizers is supplied. The effect of sprinkler irrigation is the same as that of common irrigation. However, 20% of water can be saved by sprinkler irrigation. The yield of retted fiber with both sprinkler irrigation and fertilization will surpass that without irrigation by 53%.

(iv) Studies on the effect of cultivating methods on the yield and quality of jute and kenaf fibers: The proper amount of fertilizers and date of harvesting for these fibers are being studied.

3. Natural Crossing in Jute

Studies on this problem were made both in Taipei and Chiayi in 1953 and 1954. The results obtained were as follows:

(1) In Taipei and Chiayi, the three distances in row-spacing, i.e., 45, 60 and 80 cm., did not make any significant difference in natural crossing percentage when different varieties were grown side by side. It was concluded that the 60 cm. row space, long adopted as the standard for breeding plots of jute to keep stock seeds pure, did not have an advantage over the 45 cm. row space in reducing natural crossing percentage.

(2) The three specific row spaces in Chiayi tended to show a higher percentage of natural crossing than in Taipei. But the difference was not statistically significant and more data are necessary before a final conclusion can be drawn.

(3) With the same 45 cm. row space but with different number of rows in a plot, it seemed impossible to keep jute varieties from being crossed naturally in both Taipei and Chiayi. But in the 9-row plots, the percentage of natural crossing might be reduced to as low as 0.12–0% in the central rows. The average percentage of natural crossing in the central rows was 0.06% in Taipei, and 0.07% in Chiayi.

(4) With a few exceptions, the percentage of natural crossing in the two regions ranged from O to 1.88% in all the treatments under investigation. In most cases, the percentage obtained in the studies was less than 1%.

(5) During the period of jute anthesis, little evidence was found that insects were responsible for the natural crossings in the two regions. It may be concluded that wind played an important role in the dissemination of jute pollens. To avoid or reduce the chance of natural crossing, the choice of planting distance and arrangement of jute varieties in plots with respect to the direction of prevailing winds should not be neglected. At the same time, consideration should be given to the characteristics of jute varieties such as plant type and height, branching habit, duration of blooming period, etc., so that the best possible arrangements can be made for them.

4. Improvement of Kenaf

The improvement program of kenaf in Taiwan has been concentrated on

(1) varietal improvement for developing disease resistant and high yielding varieties, and (2) improvement of cultural practices.

(1) *Varietal Improvement*

(a) Since 1946, new kenaf varieties have been introduced from the United States for trial purposes. Among the 22 varieties introduced, Cuba C has been found quite promising. This variety is resistant to anthracnose and produces 29% more of retted fiber than the variety Madras Red under extension.

(b) In 1957, another 81 new strains were introduced from the U.S. and Cuba. Among them, BG-52-7 yields 30% more of retted fiber than Cuba C and has been extended since 1962.

(c) FS55-3021-1 was selected from Salvadorino variety in 1955. This strain is resistant to anthracnose and produces 15% more than BG-52-7 in regional test. It has been demonstrated for extension.

(2) *Acclimatization of Kenaf, Roselle and Allied Crops*

198 varieties/strains of kenaf, 70 varieties of roselle, 4 varieties of *Hibiscus Acetosela* and 9 varieties of *Hibiscus radiatus* were introduced from the United States in 1955. Through two years of observations, 20 superior varieties/strains and 73 plants of 46 varieties/strains were selected for further studies. 9 varieties of kenaf from Iran and 7 progenies from the hybridization of kenaf and roselle from the United States have been studied since 1967. Among them, one variety with smooth stem and another with early maturity will be selected for further studies.

(3) *Improvement of Cultural Practices*

In the improvement of cultural practices, emphasis has been placed on the basic methods of cultivation. The important findings are summarized as follows:

(a) The proper time for sowing kenaf should be in the middle of April, and that for seed production could be postponed to late June or early July.

(b) Kenaf will give higher fiber yield and better quality if allowed to grow 120 days after germination. For seed production, the plant should require another 30-40 days after the blooming time in order to reach the stage of seed maturation.

(c) The practical rate of fertilizer application for kenaf should be 100 kg. of N, 40 kg. of P_2O_5, and 60 kg. of k_2O/ha.

5. *Improvement of Roselle*

(1) *Regional Adaptability in Taiwan*

To determine its regional adaptability in Taiwan, roselle, together with jute and kenaf, was planted at 40 localities distributed in 15 counties (1958:15 localities in 12 counties; 1959: 25 localities in 13 counties) for observation and comparison. In the trials, paddy land, dry land and hilly land of different kinds of soils were chosen. The following are some of the important findings:

(a) On paddy land, jute seems to give a much higher yield than kenaf and roselle, while on dry land the last mentioned two crops yield better than jute.

(b) In some places under the dry land conditions, the germination of roselle was rather uneven, while that of jute and kenaf was quite normal. It seems that the germination of roselle requires more water than that of jute and kenaf.

(c) Roselle thrives on sandy soil, hilly land, and gravelly land with good drainage.

(d) Roselle stands the drought very well, provided that germination takes place normally.

(e) During the growing period, leaf hopper and aphis were found infesting both roselle and kenaf, but not jute. However, it was found that roselle was very resistant to root-knot nematode infestation; although damping-off, anthracnose, powdery mildew and sooty mold might attack roselle plants.

(2) *Improvement of Cultivation*

Since roselle is a new crop in Taiwan, its cultural practices, i.e., time of sowing, spacing, rate of fertilization, method of sowing, time of harvesting and control of insect pests, should be determined through intensive experimentation. The results of the experiments conducted have provided valuable information for future extension:

(a) Time of Sowing

In order to determine the suitable time for sowing, seeds of roselle were sown from February 15 to August 16, 1958 (13 sowings) in Tainan, Pingtung, Miaoli and Hualien at 15-day intervals. In 1959, sowing was done from March 1 to August 1 (11 sowings) in Tainan, Pingtung, Miaoli, Hualien and Taitung also at 15-day intervals. The field design was 8-row plots arranged in randomized blocks with 4 replications. Plants were harvested for fiber extraction 150 days after germination and the yields of retted fiber were compared.

It was found that the different times of sowing affected the height and circumference of the stem as well as the fiber yield. However, the blooming periods of the plants in the different treatments were very close to one another, varying in length less than 7 days.

According to the results of the 1958-1959 test, the optimum dates of sowing for roselle in different places in Taiwan are as follows:

Tainan: Mid March to mid May
Pingtung: Mid March to mid June
Hualien: Mid March to mid May
Miaoli: Mid March to mid May
Taitung: Early April to mid May

(b) Spacing

In 1958, an experiment on the spacing of roselle was conducted at three localities, i. e., Chunan (dryland), Houpi (sandy soil) and Wanluan (sandy soil), with 7.5 cm., 10 cm., and 15 cm., between hills and 24 cm., 36 cm., and 48 cm. between rows, arranged in split-plot design and replicated 4 times. Each plot was 6m. × 2.88m. in size. The distance between hills was regarded as the main plot.

In 1959, the experiment was repeated at the same localities with only 7.5cm. and 15cm. distances between hills, and all the other treatments remained un-

changed. The results indicate that:

(i) In planting roselle, closer spacing should be recommended. Otherwise, the branching habit will occur and yield will be lower.

(ii) Roselle has a longer growing period than jute (150 days vs. 130 days); early harvesting would affect its yield.

(iii) Proper spacing should be 7.5–15 cm. between hills and 24–36cm. between rows.

(c) Rate of Fertilization

In 1958, the fertilization experiment was conducted only at Chiayi and Tainan, and in 1959 it was expanded to include Taitung in view of the prospects of growing roselle there in the future. Five different rates of fertilization were experimented. Harvesting was done 150 days after germination. The results obtained are summarized as follows:

(i) In Tainan and Taitung, fertilized plots gave a higher yield than the non-fertilized ones. The greater the amounts of fertlizers applied, he higher the yield of fiber was obtained.

(ii) In Chiayi, the effect of fertilization on fiber yield was not significant. This could be due to the reason that the experimental plot in Chiayi had been heavily applied with compost every year. This cumulative effect of compost might have offset the effect of fertilization during the experimentation.

(iii) After comparing the increase in fiber yield and the amounts of fertilizers applied, it seems advisable to apply 1/3 of the standard rate of fertilization for jute to roselle, in order to obtain the highest economical return.

(d) Time of Harvesting

Since roselle has a much longer growing period than jute, the proper time for its harvesting to obtain maximum yield should be determined. An experiment was conducted in 1958 at Tainan to harvest the crop from 90 days to 210 days after germination at 15-day intervals; and a total of 10 harvests were made. Sowing was done on March 31, 1958.

By analyzing the results, the following conclusions are reached:

(i) Those plots in which the plants were allowed to grow for 195 and 210 days gave higher yields than all the other plots.

(ii) The fiber yield became greater with the increase of the days of growth until a period of 195 days was reached. Then, the yield dropped markedly.

(iii) With the present need for economizing the use of farm land in Taiwan, the 150-day growth period for roselle seems desirable so that enough time could be left for growing the succeeding crop.

6. Studies on the Breeding Techniques of Jute and Kenaf

(1) *Anthesis of Flowers*

The varieties used in the studies included jute White Dew and Cuba Long Capsule, and kenaf Madras Red. The following tables show some of the results obtained:

(a) Number of Stamens and Size of Pollen Grains

Variety	No. of Stamens	Size of Pollen Grains (u)
Jute		
Cuba Long Capsule	53.3	35.3±2.0×29.5±2.0
White Dew	24.8	39.2±1.8×30.5±1.4
Kenaf	—	121.83±16.9×117.49±27.9

(b) Time of Flowering

The flowers of the jute variety Cuba Long Capsule started to show from their bracts early in the morning, became fully open at 9–10 A.M. and closed at 1–2 P.M. Those of the jute variety White Dew began to appear at 7 A.M., became fully open at 10–12 A.M. and closed at 3–4 P.M. In kenaf, the corolla emerged about one day prior to opening, and the flower gradually enlarged and started to open at 1 A.M. and became fully open in the morning.

(e) Flowering as Affected by Temperature and Humidity

Variety	Temperature (C)			Humidity (%)		
	Maximum	Optimum	Minimum	Maximum	Optimum	Minimum
Jute						
Cuba Long Capsule	34.0	30.1–31.9	24.5	96.5	56–70	56
White Dew	33.9	31.1–32.0	26.3	94.0	56–65	53
Kenaf						
Madras Red	26.2	23.3–26.1	23.2	97.0	78–97	75

(d) Peak in Anthesis

The peak of anthesis in jute occured at 8–10 A.M. for Cuba Long Capsule which constitute 87.68% of the total flowers opened for the day; and at 9–11 A.M. for White Dew which constituted 86.90% of the total flowers. No flowering occurred in the afternoon in both of the two varieties.

(e) Succession of Flowers on the Plant Body

The opening of flowers on the plant body differed somewhat with the varieties. In Cuba Long Capsule, flowers first appeared and opened on the main stem and then on the lst and 2nd branches, whereas in White Dew variety, the flowers first opened on the first branch, and then successively on the main stem, second branch and lower branches. However, the two varieties had a similar sequence of flowering on the main stem and the first branch. They started from the first or the second node and then proceeded regularly from bottom upward.

Flowering of kenaf started from the lowest part on the stem. In the early flowering period, the daily flowering number was usually small, which gradually increased in the middle of the period, and again decreased in the later part of the period.

(2)*Pollen Germination Study*

(a) The best concentration of sucrose solutions for pollen germination was found to be 25% for Cuba Long Capsule, 15% for White Dew, and 50% for Madras Red.

(b) The concentration of sucrose solutions best for pollen germination and that best for the elongation of pollen tubes were not the same. This might be due to the differential response to osmotic pressure between the two stages.

(c) The ability of pollon to germinate was usually inferior in White Dew than in Cuba Long Capsule, possibly because of the incompatibility in cross fertilization between the two jute varieties due to their differential response to osmotic pressure, beside their other characteristics.

(d) Both in jute and kenaf, the pollen grains from flowers of the day, no matter whether they were collected before or after the opening fo the flowers, could be germinated. The largest percentage of pollen germination occurred in jute was about the time of anthesis, while in kenaf, it was at a later stage of flowering.

(e) Emasculation of flowers one day prior to anthesis might remove the danger of selfing in fertilization both in jute and kenaf. The stigma of Cuba Long Capsule was found to be receptive on the day either before or after its opening. (For more details, see Annual Report of 1946,1947).

7. Studies on Yield and Quality of Fibers as Affected by the Time of Harvesting in Jute and Kenaf

Results of the studies in the two years, 1950 and 1951, are summarized as follows:

(1) Early harvesting of jute should not be done until the crop had a growth period of more than 100 days. Otherwise the yield would be seriously affected.

(2) Under similar planting conditions the effect of early harvesting on yield was less in kenaf than in jute.

(3) When harvesting of both crops was done at a proper time, the tensile strength of their retted fibers did not show any significant difference, and their fibers might be substituted for each other. The tensile strength tended to be weaken when jute was harvested less than 100 days in growth period, and when kenaf was harvested more than 140 days in growth period.

(4) There was a close connection between the development of fiber cells and the yield of retted fibers.

Further studies on the effect of cultivating methods on the yield and quality of jute and kenaf fiber, including the suitable amounts of fertilizers and times of harvesting for fibers, have been made this year. Attention will continue to be paid to the study of the quality of retted fibers from these experiments, incluing tensile strength, flexibility, shearing strength, wearing strength, fineness etc. in the fiber testing laboratory of the Tainan Fiber Crops Experiment Station.

K. Sisal

Sisal (*Agave sisal*) is indigenous to Central America. Although it is drought

resistant, it can be grown economically only under well defined conditions of rainfall and temperature factors which grovern its rate of unfurling new leaves.

Sisal has been planted in Taiwan since 1901. Its fiber is chiefly used for making marine cordage to meet the growing needs of the navy and the fishing industry, with a rather small percentage left to be used on the farms as tying and wrapping twines. However, the acreage of sisal in Taiwan is still maintained at about 10,000 ha. Most of the sisal fields are located on sub-marginal hillsides of sandy soil overlying coral limestone in the southern part of the island along both the east and west coasts.

Land utilization-Centrosema, black bean and peanut have been cultivated between sisal rows as cover crops or intercrops in the experiment. In the producing area of Hengchun, sisal has been grown continuously for the past 50 years. The lands are without rest; and new plants are usually set between rows on four-year-old plantations.

Nursery techniques — Both bulbils and suckers are used as planting materials. Being too flexible to be grown in ordinary fields, they are first cultivated in nurseries for 1 to 2 years under careful management. Where fiber yield and leaf length in fields are concerned, bulbil is better than sucker for use as seedling.

Field establishment and spacing (planting techniques), crop management, and weed control-Sisal is planted mostly on slopes in Taiwan. For soil conservation, the following two methods have been recommended: (1) Bench terrace with distances between rows and plants spaced at 2m. and 1m. (2) Hillside ditch with distances between rows and plants spaced at 2.5m. and 0.8m. Closer spacing of plants at 1.67m. × 0.6m. could bring higher fiber yield as indicated by initial results of experiment, whereas the leaves of adjacent plants would often be injured by the terminal sharp spines of each other in the event of strong wind. The quality of fiber from such injured leaves would thus be affected.

Methods of harvesting—Harvesting starts from 3rd to 4th year after planting. The lower and outer old leaves are cut off first. Usually, harvesting is done once at intervals of 8-12 months. When the leaves commence to drop down to an almost horizontal position, at least to an angle larger than 45° measured from the center of the plant, it is the proper time for harvesting. 12-15 upper leaves should be left uncut on the plant. The plants from excessive harvesting grow old fast and can not produce fibers of good quality.

Methods of extraction and drying-The Tainan F.C.E.S. (Fiber Crops Experiment Station) Type A Power Decorticators, which are driven by 4-5 H.P. diesel engines, move from farm to farm. The efficiency of this type of decorticator is higher than that of Ikeda Type decorticators. In extracting practices, one decorticator is operated by a work team of 5-6 persons. Usually, about 200 kg. of dry fibers can be produced during an 8-hour work-day. Fibers, after being extracted, are spread out on the ground for drying. They are usually kept there over-night to be wetted with dew that makes fiber white and more glossy.

Grading--The grading of sisal fiber in Taiwan is done according to the following requirements:

Item	Fiber length cm	Fiber Color	Mixture content
First grade	90 cm. up	white and bright	below1%
Second garde	75 cm. up	green and bright	below 1%
Third grade	60 cm up	pale and dull	below 5%

For measuring the optimum dosage of NPK elements, a fertilization test has been conducted in Taitung and Hengchun. The N-P_2O_5-K_2O ratio of 100-50-100 kg/ha. in Hengchun and 100-50-100 kg/ha. in Taitung are commonly recommended. The effect of N fertilizer has been manifested in the experiment which consisted of 14 treatments and was carried out for the maintenance of soil fertility in three localities: Hengchun, Taitung and Hualien. The N-P_2O_5- K_2O ratio of 180-120-150 kg/ha. plus $CaCO_3$ 3000 kg/ha. was found to be better than other treatments.

For the purpose of ascertaining the effects of nutrient deficiency in sisal plant on its growth and also the resulting physiological diseases, a study has been conducted in Tainan. In N-deficiency,P-deficiency, K-deficiency and S-deficiency treatments, the plant growth is the worst, with the number of leaves, the leaf length and leaf width all reduced to the minimum. The belt yellow disease in K-deficient plot, the purple leaf tip in P-deficient and chlorosis in N-deficient plot are very serious. In P-deficient and N-deficient plots the rate of absorbing the main elements is the least. It proves that the sisal plant requires the N-element most, followed by phosphorus, sulphur, potassium and calcium:

L. Sunn Hemp

Sunn hemp (*Crotalaria juncea. L.*) is an important green manure crop in the fields of sugar-cane and other crops in southwestern Taiwan. Its fiber can also be utilized as raw material for manufacturing cigarette paper, high-grade paper, ropes and bags.

33 varieties of fiber-type *Crotalaria juncea* have been introduced from Pakistan, India, Brazil, and U.S.A. Among them, 4 varieties have been selected and put into regional tests for developing dual-purpose varieties for both green manure and fiber production.

The results of the tests reveal that the varieties Kawnpur 12 and Selecaō-SPF/59 give the highest fresh plant yields which are between 28,859 and 31,380 kg/ha. or 5-14% higher than that of the native variety. Their dry-fiber yields are 1040-1044 kg/ha. or 37-38% higher than that of the native variety. Their pulp quality is also better than that of native variety.

The suitable sowing time is around April for the dual-purpose of green manure and fiber production, but it may be from July to August for seed production. Sowing in April will make it possible to harvest sunn hemp in July to fit in with the cropping

system of sugarcane which should be planted in August.

M. Kudzu

There are three kinds of kudzu: wild type, tropical type, and the cultivated type. All of them originate in Asia. A kind of wall paper can be made from the fibers extracted from kudzu, which is used in handicraft and art work in Japan. Hence the fiber from kudzu is sought by Japanese factories as an important raw material.

Kudzu can be planted on slope land under 1000 m. in altitude. Tests on extracting methods and planting on density have been conducted by the Tainan Fiber Crops Experiment Station. The results indicate that in fiber extraction the vine should be boiled for 20-30 minutes, soaked in water 12-14 hr., fermented 24-72 hr., and then bleached in rice-brain water 3-4 hr. The fiber obtained will have a brilliant luster. The retting percentage is 2%. With regard to planting density, 12,000 hills per ha. will give the highest yield of vine.

N. Researches on Crop Physiology

1. Studies on the Daily and Seasonal Variations of Photosynthetic Activities in Rice

Four rice varieties were used for the study in order to determine the daily variation in sugar content of the rice leaf and rate of CO_2 assimilation. Their daily variations between different stages of growth were also compared so as to elucidate the photosynthetic activities during the whole stage of growth of the rice plant. The results may be summarized as follows:

(1) The content of soluble sugar in rice leaf increased very rapidly in the morning, slowed down at noon, and reached to the peak at 2-3 p.m., then gradually dropped thereafter, and became least in amount just before the dawn of the morning.

(2) The occurrence of daily maximum content of soluble sugar in rice leaf varied rather greatly during the growing period. According to the result of studies of the 2nd rice crop in 1944, the content of soluble sugar increased immediately after transplanting. The first peak in the content of soluble sugar was seen at the maximum tillering stage. The content gradually decreased thereafter and rose up again until the period of ten days before heading. The 2nd peak in sugar content appeared at the time of heading. It went down thereafter and became in stagnant untill the end of growth plant.

(3) Result on analysis of sugar content of the 1st rice crop in 1945 which did not correspond to that of the 2nd rice crop in 1944, so far as the seasonal variation of sugar content in the leaf of rice varieties is concerned. The record of the 1st crop in 1945 indicated that the maximum content of sugar was seen during the maximum tillering stage. The content of sugar gradually decreased thereafter untill the heading period. In 1944, at the heading stage of the 2nd crop, the increase of sugar content at the second peak was much greater than in the first peak at the maximum tillering stage. This may be due to the incomplete cessation of vegetative growth during the maturing stage of the first crop.

(4) At the various growth stages, the daily changes in the content of reducing sugar were not conspicuous. Owing to the fact that the amount of reducing sugar was less than that of sucrose. So consequently the variation in sugar content was largely due to the presence of sucrose.

(5) It was clearly shown that the assimilation of CO_2 increased very rapidly under the morning sun light. The rate of assimilation became moderated thereafter and reached to its full capacity after being exposed to sun light for about 3 hours. It gradually reduced until noon. From afternoon to sun-set, the rate of assimilation maintained a constant.

(6) When two curves showing seasonal variations of the sugar content and the amount of CO_2 assimilated were compared, they did not coincide with each other. The lowest content of sugar occurred at 10-20 days prior to heading. Where as the assimilation of CO_2 was at its maximum just in the same period. It seems reasonable to suppose that the low content of sugar may be due to its rapid translocation. Because of rapid translocation of the sugar which accelerated the assimilation of CO_2, the absorption of CO_2 must have concomitantly increased.

(7) If the assumptions presented above were valid, the rapid increase in the rate of CO_2 assimilation must be the result of deficiency of sugar in leaf. At noon time, the sugar reserve may reach its maximum amount in leaf, so that the rate of CO_2 assimilation will be gradually decreased. The maintaining of constancy in CO_2 absorption in afternoon may be attributed to the balance in the rate of translocation of products from the assimilation.

2. *Preliminary Study on the Relationship Between Photosynthesis and Yield of Rice*

For the purpose of discerning the relationship between the rate of assimilation and the yield of rice, four varieties of rice including Taichung No. 65 (japonica type), and Low-Foot-Liu-Chow (a local variety, indica type) were used. The result may be briefly stated as follows:

(1) No apparent relationship was observed between the content of chlorophyl in rice leaf and the rate of photosynthesis as well as the yield of rice. This is because the photosynthetic activities were also controlled by a number of other factors.

(2) The ability of sugar synthesis was found to be greater in the indica type than in the japonica type. However, the former usually yielded less grains than the latter, although the reverse was the case in the yield of straw between the two types. Apparently, comparision of results on the two different types of rice.

(3) There has also been shown to exist relationship between the yield of japonica type and the rate of photosynthetic activities before the middle of June. No such relationship has yet been seen in rice varieties native to Taiwan.

(4) In the comparision on nitrogen content, it was shown to be lower in the afternoon than in the morning. No appreciable relationship connected to the nitrogen content in a unit weight and the yield, has been detected.

3. *Comparative Studies on the Physio-chemical Characteristics of Indica and Japonica Types of Rice*

The materials used for studying their ecological and physiochemical characteristics included the early matured varieties of indica type from Mainland China and japonica type developed in Taiwan. For yield comparisons, varieties were tested, among them 16 belonging to the indica type and 14 to the japonica type; for characteristic observations, a total of 48 varieties were used. Out of which, 21 belong to the indica type, 19 to the japonica type and 8 to glutinous varieties. The following presents the summarized results:

(1) In the yield trials, the japonica type tended to possess higher yield potentialities than the indica type when the former was grown under a closer spacing with a smaller number of seedlings per hill, and also with a proper amount of fertilizers.

(2) For the comparisons of some important agronomic characters, their range of variability was greater in the indica type of mainland origin than those varieties of japonica type bred in Taiwan, The yield component such as number of tillers, length of panicles, number of kernels, etc., were inclined to be more in a positive than in a negative direction in the japonica varieties. The regression lines representing their yield gave a higher value than that of the early varieties of indica type of mainland origin.

(3) The chemical analysis indicated a higher composition of sugar and fats but a lower value of protein and starch content in the japonica varieties than in the early varieties of indica type, The glutinous japonica type surpassed all the nonglutinous rice of both types in the content of sugar and fats.

(4) Although the japonica type of rice varieties contained more sugar and fats, and its table quality may be more acceptable to some one, yet they were poor in the capacity of expansion by cooking. The indica type rice was found to be rich in protein and starch content, and good cooking, quelity.

4. *Investigation on the Respiration Activity of Germinating Seed of Rice*

It has been true in both types of rice, the indica and the japonica, that the amount of CO_2 dissipated during respiration by the germinating seeds increased with the raise of temperature and also in proportion to the time prolonged. Under the temperature treatment with three different levels, namely 50°C, 35°C and 40°C, the germinating seeds of all the japonica varieties liberated less amount of CO_2 than that of the germinating seeds of indica type.

5. *Study on Daily and Seasonal Changes of Nitrogen Absorption of Paddy Rice*

The amount of NH3-N absorbed by rice roots from 9 a.m. to 3 p.m., was more than that of absorbed from 3 p.m. to 9 p.m. The quantity of nitrogen absorption of rice plant increased were similar in both crop seasons, its peak was found during 60-70 days after transplanting in the first crop, that peak in second crop appeared 10-20 days earlier than that of first crop.

6. *Comparative Study on Composition Outstanding Varieties of Rice in Taiwan*

Twelve Ponlai varieties (japonica type) and eleven native ones (indica type) were used for chemical analysis. The composition of rice in average value of each group, is shown in following table:

Variety	Ash %	Protein %	Ether extracts %	N-free extract %	Sugars %	Pentosans %	Coefficient of viscosity dyne-sec/cm²
Ponlai Rice	1.73	8.62	3.28	85.35	1.45	2.80	3.79
Native Rice	1.79	9.68	3.27	84.42	1.06	2.80	2.67

7. Effect of Manure Amount on N,P and K Content between Straw and Node of Rice Plant

The contents of three elements in straw and node are varied with the amount of fertilizers. Above all, the contents of nitrogen and potassium were apparently affected. The three elements stored in nodes were more than those in straws.

8. Comparative Studies on Different Varieties of Rice Regarding Water Absorption at Various Growth Stages

For the basic information of irrigation method of paddy field in Taiwan, six "Ponlai" varieties (japonica type) and six "Native" ones (indica type) were used. The results are summarized as follows:

(1) Water absorption by rice roots through the growing period showed bipeak curves, as the amount of water absorption increased from the growth of plant till head-sprouting stage, then fall down to certain extent at heading stage and then increased again at soft-dough stage, after that droped quickly. The amount of water absorbed by rice plant at soft-dough stage of the first crop was more than that of heading stage under the high temperature and low humidity conditions.

The curves of relative quantity of water absorption (the net amount of absorbed water over the amount of water evaporated from water surface, A/E), however, became monopeak curves at heading stage.

If comparing these curves with absolute water absorption curves and the curves of temperature and humidity, it can be found that the water absorption of rice plant from head-sprouting till soft-dough stage is relatively sensitive to the effect of climatical factors.

(2) Intervarietal difference in the quantity of absorbed water was significant, especially between "Ponlai" and "Native" varieties. "Ponlai" varieties were smaller in absorbing rate. It was due to the differences in size of rice plants, number of leaves and distances between the tillers etc..

(3) The difference of water requirement for producing one gram of grain among rice varieties, was also significant.

(4) The remarkable differences of water requirement among the localities and between two crop seasons were observed. Generally speaking, the water requirement of rice in South Taiwan of the first crop season were distinctly higher, because the water absorption of rice plant was clearly affected by the atmospheric environments namely it was increased in the proportion to the temperature and to the velocity of wind, but inversed the proportion to the humidity of air; and the duration of

growth of rice plant was another inportant reason.

9. Study on Photoperiodic Response of Rice Plants

This study had been done in the second crop of 1953 by using Simo-furi and Chin-kuo-chiam, the native varieties. The short-day treatments were applied that the rice plants were set under 8 hours of sun light for 6 days at various growing stages for investigating the most affective period of treatment.

(1) The effects of short-day treatment on the heading date and the days needed for whole heading period between two varieties in second crop, were the same.

(2) The rice plants from 10th to 21st day after transplanting showed sharp photosensitiveness and high acceleration of heading date, but the duration of heading was extended on the contrary. The rice plants treated from 21st to 29th day showed the same response, but their durations of heading were never extended.

10. Observation on Differentiation of Floral Bud of Rice under Natural Condition

Taichung No. 65 (japonica type) and Taipei-Ukuo (indica type) were used for the comparative observation. The transplanting date of first crop was March 4th and on August 7th in the second crop. Samples of five plants for each variety were taken every day during the growing period to observe the differentiation of floral bud in Taipei. According to the results shown in following table, it can be concluded that:

(1) The number of days from the transplanting to the beginning of primordium differentiation: Taichung No. 65 was 6-10 days earlier than Taipei-Ukuo, then which of the same variety was accelerated 18-22 days in the second crop.

(2) The number of days from the beginning to the end of differentiation: Taichung No. 65 was 3 days longer in the first crop, However it was inversed in the second crop.

(3) The number of days from the beginning of differentiation to the heading: Taichung No. 65 was 2-4 days earlier. Which of both two varieties was accelerated 5-7 days in the second crop.

Crop season	Variety	From transplanting to beginning of differentiation	From beginning to end of differentiation	From beginning of differentiation to heading	From end of differentiation to heading
1st	T—65	46 days	21 days	35 days	14 days
	T—U	56	18	33	15
2nd	T—65	28	15	30	15
	T—U	34	18	26	8

11. Studies on Rotational Irrigation of Paddy Rice

The studies were carried out in order to find out the method of water-saving irrigation, to overcome the shortage of water resources in Taiwan by rotational irrigation system. The studies was carried out at Chung-Ing, Tainan Hsien, under the assistance of Joint Commission on Rural Reconstruction, Rotational irrigation Promotion

commission of Taiwan and Chia-Nang Irrigation Association during 1955-57.

An experimental farm was set for precise experiment. On the other hand, 110,85 hectares of rice fields were set as the rotational irrigation observation area which divided into four plots so as to practice the rotational irrigation methods in experimental farm to observe the practical problems at the same time. The conditions of experiments were under record making drought continued three years in the first crop, but under heavy irrigation during early growing stage of the second crop. The rice variety, Chia-Nang No. 8 (japonica type) was used for the first crop and Bin-Tan (indica type) for the second crop.

The irrigation methods were as follows: Continuous irrigation plot: 20-45mm depth of water was kept but the water was drained about 3 days for every time of weeding and drained 6-8 days at the elongation stage. This was the continuous irrigation method which the water was fairly saved.

6-day, 8-day, 10-day and 15-day rotational irrigation plots: Irrigated with 45 mm depth of water every time according to each rotational interval. The 15-day rotational irrigation method was taken one time only and changed with 5-day rotational irrigation method.

5-day rotation irrigation with controlling water depth according to the stages of growth: 30mm depth of water was supplied untill very-young-head forming stage, then 50mm depth of water was supplied from the very-young-head forming stage till the end of heading stage, after that the water depth was cut down to 30mm again.

Results:

(1) In the small experimental farm, there were no significant differences in plant height, panicle number and heading date among the different methods of irrigation.
(2) The difference in grain yield was also insignificant in the first crop (Ponlai Rice) except 15-day rotational irrigation which was 14% less than continuous irrigation plot (6.4 MT/Ha). But in the second crop (Native Rice), the yield of rotational irrigation plots were 4-6% lower than that of continuously irrigated plot (3.7 MT/Ha).
(3) The percentage of water saving by rotational irrigation methods were about 30-60% as compared to continuous irrigation method.
(4) But according the results observed in large irrigation observation area, it was necessary to increase the irrigation water after head-sprouting stage when the rotational interval was more than 6 days and the water depth of each irrigation was 45mm, so the 5-day rotational irrigation with controlling water depth according to the stages of growth was the best water saving rotational irrigation method for rice. In view of this, the old irrigation rule of Chia-Nang Irrigation Association which had been practiced for about 30 years, was changed.
(5) The good rotational irrigation overcame severe drought in the first crop season and brought a good harvest (6,000 kg/ha). One of them even got the third prize of all provincial yield contest with the yield of 8,340 kg/ha.

12. *Study on Physiological Causes of Different Yield of Rice between First and Second Crop in Taiwan*

The yield of rice in the second crop is about 15% lower than that of the first crop in Taiwan. People have made a rough surmise of that reason was due to the shorter period for growth, but it seems that its important reason may be due to effect of temperature change to the physiological action of rice.

This study was carried out in a greenhouse so that the rice might free from the effect of typhoon, but all of its windows were opened in ordinary days to keep the temperature as usual. The pot cultural method was applied for the purpose of the rice roots can be well washed out from the soil. And the kinds of pots which suitable for the development of rice root system were used. The growth analysis method was applied; the leaf area and the oven dry weight of whole plant were determined every other week to compute the Leaf Area Ratio and the Net Assimilation Rate so as to find out the differences of its changing pattern between the two rice seasons. The Migration Coefficient and the sterility of rice heads were also investigated.

The results are summerized as follows:

(1) In the first crop, the average temperature rose up from 20°C to 30°C. On the other hand, it fell down to 17°C from 30°C in the second crop. Under this condition, the rice plants of the first crop could have twice of the active leaf area caused it grew two times of the effective tillers based on which of the second crop; so that the Leaf Area Ratio during the reproductive growing period of the second crop, was lower than that of the first crop.
(2) In the second crop, the Net Assimilation Rate in two important growing periods (from the head-sprouting to the heading stage and after soft-dough stage), were apparently lower than those of the first crop.
(3) The sterility of the rice flower in the second crop was three times higher than that of the first crop, because it had passed the reproductive growing period under lower 22°C which is the critical temperature of the sterility of rice.
(4) The rate of transmission of synthesized substances to the panicles (Migration Coefficient) in the second crop, was 55% of that of the first crop only.

13. *Studies on Immediate Cause of Akgagare Disease of Rice Occurred in Middle and South Taiwan*

About 13,000 hectares of paddy fields sufferred severely from mysterious disease in Pintung Hsien in the second crop of 1960. The sick rice plants showed apparent symptoms of the second type of "Akagare disease"—a kind of the suffocating disease—which occurred in Japan(according to the classification made by Dr. I. Baba): the disease occurred in the tillering stage, the plants become yellow in color then appeared the necrosis from the tops of the lower leaves, and withered up with the redish brown color; the roots had been rotted with bad small. So it seemed to be that its immediate cause should be the poisoning due to the hydrogen sulfide and the ferrous iron or the organic acids. The same disease have been occurred in the Middle and South Taiwan since 1960. Somebody, however, said that the hydrogen sulfide should not be the cause of it, because all of the soils have enough free ferric iron in Taiwan.

These studies were carried out to make the cause of disease clear stood on the viewpoint mentioned above from 1962 to 1964. The investigations on the symptoms of sick plants and the profiles of its soils were taken; on the other hand, the determinations of the sulfides and the ferrous iron in the sick plants were also done by using the micro-chemical methods: 2.5% solution of ~~lead~~ zinc acetate was used for the detection of sulfides; 0.2% solution of O-Phenanthroline was taken for determining the red color reaction to ferrous iron at the short time; then the distributions of the granule black ferrous sulfide and the ferrous iron in the sections of tissues were also observed with the microscope. The results are summarized as follows:

(1) The sick rice plants occurred in the Middle and South Taiwan showed the same symptom of the second type of "Akagare disease" but the roots never rotted in this case; moreover they were accompanied by brown spot owing to the helminthosporium.

(2) From the surveys of the profiles of sick soils, we found that the iron and the manganese permeated into the deep layer of soil, and the deficiency of iron in the plow layer was very clear at a glance. Then there was the interrelation between the degree of the occurrence of the akagare disease and the devolution of the soil.

(3) In two cases, the facts that much smelly solution of hydrogen sulfide stored in straws were found. And the dense sulfide was also determined from the basal tissues of straws, the leaf sheaths in the soil, the nodes, the buds of tillers which occurred the necrosis and the roots. The mass of granular black ferrous sulfide was also found in those tissues especially in the basal tissues of straws and the nodes on the lower part of straws, then many vascular bundles were clogged up with them. A lot of cells also showed in gray color. Some of basal points of roots fitted on the basal tissue of straw were transformed and showed thick black color.

(4) The dense ferrous iron was also detected in the tissues mentioned above, especially in the vascular bundles, the cortical tissues of roots and its central cylinders. The mass of large-grained or in beads of ferrous iron was found in the parenchymas of basal tissues or in the central cylinders on the basal points of roots; in addition to this, many vascular bundles were clogged up with it.

(5) According to the facts mentioned above, it can be proved that the immediate cause of the akagare disease occurred in the Middle and South Taiwan is the poisoning due to the rice roots absorbed much hydrogen sulfide and the ferrous iron under the high temperature and the reduced condition of devoluted soil. Then the poisoning owing to the organic acids may also be assumed to another reason of the disease.

(6) This disease might increase in Taiwan because the degree of occurrence of the akagare disease was corelated to the degree of degeneration of the soil, if the soil reclamation would not be conducted and it was unseasonable weather.

14. Water Absorption by Sweet Potato as Influenced by Some Environmental Factors Observed at Taichung Taiwan during the Course of Solar Eclipse on Cloudy Day

This study deals with the absorption of water by sweet potato as influenced by some environmental factors observed during the course of solar eclipse on a cloudy day-May 9th, 1948. The observed results may be summarized as follows:

(1) The change of environmental factors during the course of solar eclipse on a cloudy day shows the same tendency as those of a fine day as observed in Senday, Japan and Satporo (June 16, 1936) and Taipei, Taiwan (Sept. 21, 1941), that is the time of minimum value of the factors coincided with time of climax of eclipse. However in the present case, the evaporation was apparentely affected by solar eclipse, it coincided with the example of Taipei, but it contrasts to the case of Senday and Satporo. The maximum humidity occurred at 12 minutes before the climax of solar eclipse, then the humidity decreased quickly with restoration. The minimum temperature occurred at about 2 minutes later than the time of climax of eclipse.

(2) The water absorption of sweet potato decreased with the degree of eclipse and increased with its restoration. The tendency took the form of a concave curve with minimum value as the bottom. The minimum value occurred 7 minutes later than climax of solar eclipse. This tendency coincides with that of former researches.

(3) According to chen's observation in the same time using sugar cane as indicator plant, the time of minimum value of water absorption occurred about 13 minutes later than that recorded by Tamai on a find day (Sept. 21, 1941). Furthermore under the same condition, the time of the minimum value of water absorption of sweet potato took place 8 minutes before that of the sugar cane. The time of minimum value of temperature lagged after the climax of the solar eclipse, was shorter than that in the case of evaporation or absorption. This tendancy also coincides with the records of former observers.

(4) According to the observed results, the water absorption of sweet potato decreased to about 55.5% of normal day's, the evaporation was 55.93% and the temperature was 23.57%. The evaporation and water absorption were positively corelated as shown by the former record observed at Taipei. Therefore, the evaporation from atmometer may be taken as the index of the water absorption of sweet potato.

(5) The response of plant and the change of the observed environmental factors in course of the partial eclipse on a cloudy day differs from that a total eclipse on a fine day only quantitatively.

15. Studies on Physiology of Jute, Kenaf and Roselle

Cold tolerance of seed and seedlings, photoperiodism and light intensity in jute, kenaf and roselle have been studied since 1964. Some of the results obtained are described briefly as follows:

(1) The order of growth rate in the seedling stage is kenaf, jute and roselle.

(2) Cold injury during the germination of seeds will be serious if the seeds soak for a long time before treatment at O°C. In general, it would have little effect on germination to soak seeds at 15°C. for less than 48 hours before treatment at O°C.

(3) The cold tolerance of the seedlings of different varieties is kenaf, roselle and jute. The injury to seedlings becomes serious in proportion to the duration of low

temperature and height of seedlings.

(4) The vegetative growth days of different crops or varieties vary among themselves and increase with the increase of daily photoperiod.

(5) According to the effects of light treatments on vegetative growth days, all the varieties of the three crops are short-day plants. The different effects are due to their different turning points in photoperiod. The adaptability of roselle is the widest, and that of the jute variety Solimoes is wider than that of other varieties.

(6) The vegetative growth days of different degrees of light intensity are usually longer than that under natural conditions (CK). It might be due to lower temperature in the shelter.

(7) The plant height of different crops or varieties increases with the decrease of time under shelter. Their plant height under light intensity of 36% is higher than that of 16%.

From the above it is believed that jute should not be sown before March. Although kenaf is tolerant to cold, it will be of economical value to sow too early due to its slow and abnormal growth at low temperature and short-day period in Taiwan.

O. Researches on Genetics and Cytogenetics

1. Studies on the Behavior of Chromosomes in Tetraploid Rice Plant

The present experiment deals with the behavior of chromosomes in the pollen mother cells of artificially induced tetraploid rice plant, with special reference to the differences between strains induced from different varieties and the hybrids of those strains.

Predominantly quadrivalents and bivalents were found beside few univalents and trivalents. Generally speaking, such types of pairing as 9IV+6II, 8IV+8II, 7IV+10II were found most frequently at diakinesis or metaphase. The number of quadrivalent chromosomes was different with strains and was generally larger in autotetraploid strains than in their hybrids.

At the first metaphase and anaphase, the number of univalent chromosomes in the hybrid plants was lower than in the autotetraploid strains. Intimate secondary pairing was found between two homologus bivalents, and the frequency of secondary pairing in the autotetraploid strains was lower than in the hybrids. Normal disjunction of chromosomes was found in first anaphase in a majority of cases. From the results mentioned above, it seems that there may be a slight differential affinity among the chromosomes of different varieties.

2. Studies on the Development of Embryosac and Pollen Grain in Tetraploid Rice

The present experiment deals with the development of embryosac and pollen grain in tetraploid rice which was observed in order to gain information on the cause of sterility of tetraploid rice. Deterioration was found to become visible at one nucleus stage (after the collapse of outer three cells of an embryosac tetrad) and seemed to increase with the progress of stage.

At the time of maturation, different types of irregularities were found ranging from such that the embryosac cavity was filled by nucellar cells to nearly normal

ones. The higher the degree of change, the earlier the stage of beginning of deterioration. At the time of heading, abnormal embryosacs were found in about 2/5 of those observed. This ratio is much lower than the percentage of sterile seed. Since the assortment of chromosomes seems to be numerically normal in a greater part of cells the sterility in tetraploid plants may be mainly due to some physical disturbances. Good pollen percentage was higher than the percentage of fertile seed.

3. Studies on Behavior of Chromosomes and Development of Embryosacs and Pollen Grains in Haploid Rice Plant

This experiment was aimed at to observe the behavior of chromosomes in meiosis and the development of embryosacs and pollen grains in haploid rice plant. Two haploid plants were observed; in both of them, pollen mother cells at diakinesis of first metaphase were found to have one or two bivalent chromosomes. This seems to suggest that certain chromosomes in haploid set are to some extent homologus with each other.

The second division was not found in a majority of pollen mother cells. This seems to be due to the failure of the first division. In a larger of cases, two or three megaspores were formed from an embryosac mother cell and they seemed to degenerate soon. No normal embryosac tetrad was found. The number of microspores produced from one pollen mother cell varied from two to four. The haploid plants were completly sterile due to the failure of meiosis such as mentioned above.

4. Cytological Studies of Sterility in Hybrids between Distantly Related Varieties of Rice Oryzae Stativa, L.

With a number of rice varieties and their F_1 hybrids, the behavior of chromosomes in pollen mother cells was investigated. The occasional occurrence of univalent chromosomes, "stretched chromosomes," and anaphasic bridges was pointed out. All of the abnormalities were found both in F_1 plants and in parental pure lines, and in the frequency of occurrence of these phenomena, the F_1 and parental plants did not differ significantly. Thus the anaphasic bridge cannot be attributed to inversion. An explanation may be that come from an occasional reunion of sister chromatids after a breakage at the diplotene stage in meiosis.

5. Isolation of Reciprocal Translocation Lines in Rice

The semi-sterile plants induced by X-ray irradiation were studied cytogenetically. It was found that, semi-sterile plants gave 1 fertile and 1 semi-sterile segregation ratio; fertile ones bred true, while the semi-sterile ones continued to segregate in a manner as mentioned above. When the former was back crossed to original variety, it produced either all sterile or all fertile plants, and segregation of fertile and sterile plants was never seen within the same cross. Such a behavior of inheritance of fertility was attributable to chromosomal interchanges caused by X-ray irradiation. The frequency of ring, chain and other types of quadrivalents ranging from 0-100%, was found to be significantly correlated with percentage of seed sterility. It has assumed that "ring" and "zigzag" configurated chromosomes were equally frequent in the observed strains. Fifty five lines of heterozygotes for interchange and twenty lines of

homozygotes for interchange were isolated from the two treatments.

6. Analysis of Reciprocal Translocations in Rice

Fourteen reciprocal translocation homozygotes obtained through test cross of RT heterozygotes which were induced by X-rays were intercrossed. The interrelation of interchanged chromosomes of these lines was studied cytologically by the aceto-carmine smear technique. RT analysis was made regarding the following respects. In F_1s between two RT lines; (1) if all the chromosome paired normally, the parental lines would have translocations in the same chromosomes, (2) if a quadrivalent chromosome was formed, the chromosomes concerned in translocations in both lines would be the same, though it is possible that their translocations are situated in different arms, (3) if a ring of six chromosome in common in their translocations and (4) if two rings of four were found, the parental lines would have quite different translocations.

The result of RT analysis made according to this rule showed that at least three different RT lines out of 14 were identified, and five chromosomes out of 12 were involved in different reciprocal translocations within the materials. The percentage of good pollen in plant having 1⊙4, 2⊙4 and 1⊙6 were 50%, 22.9% and 17.1% respectively and showed good fits to the expectation. More RT strains are being isolated and the linkage analysis is now under way.

7. Studies on Agronomic Characters in Reciprocal Translocation Homozygotes of Rice

The RT homozygotes, 10 lines of 108 (Pei-ko), 7 lines of 521 (kissin) and 10 lines of 504 (Taichung No. 65) tested in a randomized block experiment. Various agronomic characters which are controlled by polygenes were measured and variance analysis was made. It was found that the translocation lines are generally homogeneous in agronomic characters and may be regarded as having the same genotype for translocation. However, translocation may sometimes be accompanied by genic changes. It was assumed further, that the translocation method may be used to some extent for locating quantitative characters on chromosomes and the analysis of interrelation of chromosomes is being carried out.

8. Studies on the Growth and Development of Rice Embryo Cultivated in Vitro

The abortion of embryos at stages that too early for the embryos to be cultivated *in vitro* by existing methods has been a common difficulty in obtaining viable hybrids in interspecific crosses. Accordingly, methods permitting the cultivation of such embryos from stages preceding the differentiation of axial primordia and vascular tissue might be of real significance in plant breeding. Therefore, the experiment deals with developmental process of young embryo formation and differentiation of primordia leading to the mature embryo, and the post germinated embryo culture was conducted in order to look into the nutrient requirement for the growth and development of young embryo.

The development and formation of embryo sac in rice Ta-tung-chai-lai, early maturity and photo-insensitiveness, was observed periodically after anthesis. 30 minutes after anthesis, the pollen tube has entered into the embryo sac. One hour after, one male gamete migrates into the polar cytoplasm, the other male gamete is near the top of the egg cell. The first division of the egg cell is 10 hrs. after anthesis. The differentiation of the embryo has finished until 15 days after anthesis. After that, the embryo is completely matured.

In the second study, one indica variety and three japonica strains (Bozu No. 5, N-11, kokusholuto) were used in studying the post germinated embryo culture. The results showed that the rice embryo reached the length of 0.41 mm 4 days after pollination. This is the minimum length of the embryo which can be cultivated *in vitro*. But it varied from variety to variety.

The effect of different medium on germination rate of young embryo ranged from 50% to 100%. On the contrary, the effect of vitamins winthin 15 days old embryo was not very clear but the seedlings increased height significantly. However, the effect of glucose and Casein hydrolysate on the growth of embryo was very significant.

9. Analysis of Linkage Groups by Reciprocal Translocation Method

As proposed by Burnham (1934, 1946), Yamashita (1944) and Kramer (1954), reciprocal translocations are of great value as a tool for linkage group analysis. Basides, we also intend to establish a complete set of test-strains containing translocations and certain marker genes, so as to increase facility for genic analysis in rice.

The interrelation of interchanged chromosomes of translocation homozygote lines was studied cytologically with the F_1 plants of intercrosses between different translocation homozygotes. As the results of RT analysis, it was found that five and nine chromosomes out of 12 were involved in different translocations of Taichung No. 65 and Kissin, respectively.

The further study showed that the long extra glume gene, *lng*, was to be located in the translocated chromosome of either No. 5 or No. 3 carried by 521TH-7 (Kissin). The recombination value between *lng* and semi-sterility gene was estimated to be 18%. with these results, more detail analysis can be made in the future.

10. Inheritance of Resistance to Different Races of Piricularia Oryzae

Knowledge of genetics of blast disease resistance is important to rice breeders, but rather little has been accumulated. It is generally believed that rice varieties of the *Indica* type are more resistant to the blast disease than the *japonica* varieties. However, this is not consistent with the recent finding of physiological races.

16 differential hosts of rice varieties of both *japonica* and *indica* types and some strains from U.S.A. and Japan were used to identify physiological races of the blast fungus in Taiwan. The F_2 and F_3 hybrids between 28 *japonica* rice strains were tested for blast disease resistance to four different races, 4, 13, 22, and 25. The results showed that the resistance to the four races were found to each controlled by a resistant gene (Pi_4, Pi_{13}, Pi_{22} and Pi_{25}). They were independent of each other. Also they were not linked with marker genes involved in the crosses as pigmentation, dwarf and phenol staining genes.

The resistances to the leaf and neck blast in the field conditions varied widely due to variety, year, crop season and location. In 81% of strains so far tested, leaf and neck

resistances were correlated, and appeared to be controlled by the same gene (genes). In the remaining 19%, the leaf and neck blast resistance genes were not correlated.

11. Genic Analysis for Purple Pericarps and Other Characters in Rice

In order to analyzed the genic system for purple coloration of pericarp and its linkage relations with genes for other characters, crossing experiments were made with gene marker strains from Japan and U.S.A. and some induced dwarf mutants. The inheritance of purple pericarp and splitted grains in various crosses were investigated with particular attention to their relations to anthocyanic pigmentation at various plant organs. It was assumed that two genes P_P (which is epistatic to *Pb*) and *Pb* is concerned for expression of purple coloration in pericarp. A close linkage between *Pp* and one of apiculus genes *A* was found and the recombination value is 5.1–9.4%.

Purple leaf blade is controlled by a modifier *Pl* which distributes anthocyanic pigment produced by the interaction of C^B and *A* which is found to be in complete linkage with *Pb*. Further, linkages were found between one of purple pericarp gene *Pb*, purple leaf blade *Pl*, splitted grain *Gs*, stigma coloration *Ps*, ligulelessness *lg*, purple lemma and palea *Rp*, phenol reaction gene *Ph* and a dwarf gene d_9. The recombination values were estimated for each pair and the arrangement of gene order was assumed on Nagao's linkage group II. No linkage was detected between the above genes and some other genes.

12. Inheritance of Mutations Induced by Irradiations in Rice

In order to know the genetic behavior of dwarf, narrow and rolled leaves, spreading, compact spiklet etc. mutant characters and the relationships between the genes which are already known and designated. 21 out of 150 mutant strains of rice induced by radiations were picked out for genetical study. They were intercrossed or crossed with normal strains, and the segregation pattern of various traits in F_2 plants were investigated.

Most of the mutant characters such as dwarfness, spreading panicle, laziness, narrow-rolled leaf, etc. showed monogenic inheritance. In an intercross of two dwarfs, however, the F_1 showed normal plant height, but in F_2 population, 9 normal, 3 dwarf-1, 3 dwarf-11 and 1 double recessive dwarf were segregated, indicating that dwarf-1 and dwarf-11 had different genes for their dwarfness which were independent from each other. Linkage was also found between the liguleless gene and a *d* gene. Further, linkage between another *d* gene and one of the apiculus color gene *C* was also found.

13. Linkage Relations of an Induced Dwarfness Gene

A number of dwarfness genes have so far been known in rice, i.e., d_1 to d_8 by Nagao and Takahshi; d_9 by the staff member of this Institute; and some others by Indians. A dwarf and liguleless strain which derived from a cross between an induced dwarf and a liguleless strain, was crossed with 15 different strains, with the view to finding out linkage relations of the dwarfness gene concerned. The dwarfness genes, tentatively named d_{42}, was found to be located between *lg* and *Ph* in linkage group 11 of Nagao and Takahashi. The recombination values between d_{42} and *lg* ranged from

6.8% to 12.3% according to cross-combinations. The dwarfness gene d_9 wes also found to be located on linkage group 11. Its relationships with other characters which located on linkage group 11 were determined.

14. Inheritance of Resistance to Phytotoxicity of Phenyl Mercuric Acetate in Rice

The inheritance of the marked differences between rice varieties in response to phenyl mercuric acetate (PMA) dust was investigated in the first crop of 1966. The resistant japonica-type variety, Chianung 242 was crossed with a sensitive indica one, Taichung native 1, and their F_1, F_2, BC_1, and BC_2 Plants were dusted with Ceresan lime. The individual seedlings or plants were classified for resistance to PMA toxicity based on an arbitrary scale. The observed data agreed with the hypothesis that sensitivity to PMA toxicity is controlled by at least two pairs of alleles. The symbols Pma_1 and Pma_2 are tentatively designated to indicate these two alleles for high sensitivity to PMA.

P. Irradiation Experiments

Since 1948, rice has been X-rayed to obtain chromosome translocations for linkage analysis. Translocations were continuously isolated and linkage analysis is under way. Not until the winter of 1967 that irradiation experiments on various crops for practical breeding purposes were commenced through the cooperation of the Joint Commission on Rural Reconstruction (JCRR) and the Union Industrial Research Institute. Among the overall breeding objectives, disease resistance and early maturity were emphasized in the course of selection.

1. Irradiation Experiment on Rice

(1) *Artificial Induction of Mutations in Rice*

The aims of the experiment are to obtain mutations by X-ray irradiation and to take advantage of the translocations thus induced for linkage analysis. Germinating seeds of two varieties, Taichung No. 65 (a representative Ponlai or Japonica variety in Taiwan) and Pei-kuo-hua-lo (a native variety of the first-crop nature) were used. Dosages of X-ray; 4m. a., 80 k. v., 30 cm., 80–120 minutes.

The surviving percentage of seedlings of X_1 generation, ranging from 78 to 0, decreased with the increase in duration of irradiation. Taichung No. 65 is better than Pei-kuo-hua-lo in X-ray tolerability. The fertility of X_1 generation tended to decrease markedly with the increase in dusation of irradiation. The individual panicles were different in fertility even within a plant.

The frequency of chlorophyll deficiency was quite high in the seedlings of X_2 generation. Among the seedlings of Taichung No. 65 from 80-minute treatment, there occurred xanthic 2.3%, cream 8.8%, variegated 3.6% and white 1%. A dwarf type of rice only 3/4 as tall as the original variety was obtained in the X_2 generation of Taichung No. 65 with 0.2% of frequency. The dwarf mutant behaved as a simple recessive, in the cross with the normal strain. A number of semi-sterile strains were obtained in addition.

(2) *Effect of X-ray Irradiation on Agronomic Characters of Rice*

In order to study the effect of X-rays on various agronomic characters of rice,

the X-ray treatment was again applied to the treated seeds. Germinating seeds of the above mentioned varieties were used. The seeds which were socked in water for three days before treatment were subjected to 5,000 r. 8,000 r. and 10,000 r. of X-rays at Taiwan University Hospital on Feb. 17, 1954. It was found that though a certain dosage of X-rays is effective to promote or suppress plant height, number of tillers and weight of ears, but the difference among treatments become insignificant at the late growing stage. Based upon the conclusion thus reached, the possibility of obtaining new varieties with good agronomic characters in X_1 generation is considered to be relatively small.

(3) *Isolation of "Reciprocal Translocation Lines" from X-rayed Progenies of Rice*

The semi-sterile mutants found in X-rayed progenies of rice were critically and cytogenetically studied for the detection of "reciprocal translocation" lines to be used for linkage analysis.

Ten to sixty percent of pollen mother cells showing tetravalents in the forms of rings, chains and other shapes was observed in the different strains of translocation heterozygotes. Fragments and laggards were also observed. When the fertile plants from the progeny of a strain of translocation heterozygotes were backcrossed to the original variety, the F_1 plants were either all sterile or all fertile. The former case showed that the fertile parent is a translocation homozygote. By means of this procedure, 20 strains of translocation homozygotes of Pei-kuo-hua-lo were isolated for the purpose of linkage analysis.

(4) *Breeding of Disease Resistant Varieties of Rice by Irradiation with X-rays and Thermal Neutrons*

In May 1956, with a grant-in-aid from JCRR, seeds of five rice varieties were sent to the Brookhaven National Laboratory for treatments with X-rays and thermal neutrons, for the purpose of breeding better varieties. The materials thus irradiated have entered fourth generation in the experimental field. The effects of irradiation on growth rate of seedlings, heading date, percentage of semi-sterile plants have been investigated, and visible mutants were selected. Treatment with the thermal neutron was found to be more effective than with the X-rays in inducing mutations.

(5) *Comparison of Cytogenetic Effect of X-ray and Gamma-ray (from Cobalt-60 Source) on Rice*

Samples of the dormant seeds of Taichung No. 65 were subjected to various dosages of X-rays and gamma-rays (from cobalt-60 source). Without filtering, the X-ray was administrated to the seeds as they were spread in a single layer in uncovered petri dish at the distance of 25 cm. from the target tube. The radiation facility was operated at 200 KVP, 15 MA giving approximately 382 r per minute. For treatment with Cobalt-60, the seeds were put in small paper bags and exposed to cobalt-60 at the distance of 40 cm. Under this condition, 113 r per minute was given to seeds. The highest dosage used was approximately 4 hours and 43 minutes. Different dosages of both radiations ranged 500-32,000 r.

The preliminary result obtained from the experiment is as follows:

(a) The germination rate was very high as it was compared with controls.
(b) The rate of plant survivals ranged 23-46% in X-rayed seeds and 50-60% in gamma-rayed seeds.
(c) The degree of seedling injury was proportional to dosages of X-rays, but similar effect was not clearly seen in gamma-rayed plot.
(d) The range of variation of seedling height was increased in treated plot as it was compared with controls.
(e) The relation between dosages and chromosomal interchanges was also studied.

2. Effects of X-rays and Thermal Neutrons on Chromosomes of Rice

Seeds of five "Ponlai" varieties (Japonica type) were sent to the Brookhaven National Laboratory, U.S.A. for irradiation with X-ray and thermal neutrons. The relation of doses as well as kinds of radiation to the rate of chromosomal changes, and varietal differences in radiation sensitivity were studied cytologically with the first generation plants.

Ring chromosomes and univalents were found at both diakinesis and first metaphase of pollen mother cells. The frequency of cells with a ring chromosomes was proportional to the dosage of radiation. The effect of thermal neutron appeared to be more serious than that of X-rays. Dosage of radiation producing 1% chromosome interchanges was approximately 600 r with X-rays, and was 0.10×10^{13} nth/cm^2 with thermal neutrons. The biological equivalence value for chromosomal changes was then, calculated to be 1r of X-ray$=1.6 \times 10^9$ nth/cm^2 of thermal neutrons. Varietal differences in radiation response were proved with X-rayed plants but were not significant with neutron.

3. Rice Breeding Utilizing Irradiated Rice Material

Seeds of five ponlai varieties were sent to the Brookhaven National Laboratory for radiation treatment. The irradiated seeds were sown and grown in the Institute. Selection was practiced from X_2 generation for early maturing, blast resistance and high yielding capacity. Various mutated types were also selected. The X_2 material was grown in two different places of the island, one in Taipei the other in Taichung, More than 500 promising strains and about 100 mutants were selected. However, none of promising strains reached to regional yield trial. The mutants selected are kept for other intrests.

4. Irradiation Experiment on Peanut

Seeds of two varieties of peanut were sent by JCRR to the National Brookhaven Laboratory for thermal neutron and X-ray treatment in 1956. They were sent back and sown on May 8 at the Tung-shih seed and Seedling Multiplication Station at Taichung Hsien. Up to May 16, 1957 the data on germination percentage were recorded. It is now the sixth generation, and several promising lines have been discovered.

5. Irradiation Experiment on Sweet potato

Root tubers of the variety P_{30} of sweet potato were X-rayed with dosages of 1,250 r and 5,000 r at Union Industrial Research Institute from May 8, to 9. They were

planted at this Institute on May 13, 1957. Up to May 24, 1957, 14 of the 25 that 1,250 r-treated tubers, 11 of the 26 that 5,000 r-treated tubers, and all 4 of the untreated tubers have sprouted. In contrast to the untreated, about 50% of both treated plots showed variegated leaves. Besides, more tubers are being sent to Union Industrial Research Institute for the second treatment.

There was also another research entitled "The storage quality of the tubers of sweet potato after exposure to X-rays" which started in 1959. The preliminary results showed the dosage of 5,000r X-rays is the most available for storage purpose, but it resulted much decrease in vitamin A and D contents among X-rayed tubers. In 1966, 10 fixed new lines of sweetpotato are selected from the progenies of the variety Tainung No. 57 which were X-rayed during 1958-1960.

Two new lines, R66-8 and R66-19, are promising in yield of tubers that both yielded 30% more than the control variety (Tainung 57). Regional test will be carried on in the coming three years.

6. Irradiation Experiment on Soybean

Seeds of two varieties of soybean were sent to National Brookhaven Laboratory U.S.A. for treatment of X-ray and thermal neutron through cooperation of JCRR. They were sent back to the present Institute in July of 1957, and planted at the Miaoli Agricultural Vocational School for observation and selection of disease resistant lines.

7. The Effects of X-ray and Thermal Neutron Irradiations on Soybean

The results indicated that the X-ray and thermal neutron irradiations affected a certain degree of quantitative and qualitative variations in soybeans. The X-rays treatments induced wider variation in quantitative characters than that of the thermal neutron. On the other hand, the thermal neutron treatment produced somewhat higher rates of qualitative changes than that of X-rays.

For the further study of chromosomal aberations induced by thermal neutron, the dormant soybean seeds of N.K. no. 5 and Nung-shih H-14 were irradiated by thermal neutrons of two doses(A) 2.48×10^{8} for 30 hrs. and (B) 7.44×10^{8} for 10 hrs. the accumulated total dose was 2.86×10^{13} nth/cm^2.

Univalents, trivalents, quadrivalents, chromosome fragments and other multiple chromosome chains were observed at the stages of diakinesis and first metaphase of PMC in treated R_1 materials. Chromosomal bridges and lagging chromosomes were found during first anaphase. As we know, the frequency of quadrivalents and chromosomal bridges could be used as an index to detect the degree of chromosome rejoining after chromosome breakage caused by different treatments. The percentage of rejoining was 40.7% in the treatment (A) and 59.6% in treatment (B) of the Nung-shih H-14, while that of 60.2% and 73.6% in (A) and (B) of N.K. no. 5 variety respectively. It showed that N.K. no. 5 was more sensitive to the radiations than the Nung-shih H-14. There was a significant difference in induced chromosomal aberations between the treatments, the higher the flux number and the shorter the time, the more effective on the induction of chromosomal aberation. There was a

negative correlation between the percentage of stainable pollen grains and the degree of chromosome rejoining.

Q. The International Exchange of Seeds and Seedlings of Crops in Taiwan

Based on the resolution of the second Far-East Seed Improvement conference held in Tokyo, Japan in May of 1959, the government of the Republic of China, ordered Department of Agriculture and Forestry of Taiwan provincial Government (PDAF) to take action on the problem. Taiwan Agricultural Research Institute was then instructed by PDAF to set up the International Exchange center of plant materials in Taipei.

After setting up the center, all incoming and outgoing plant materials in this island should be handled, according to the regulations governing export of seeds and seedlings for farm crops from Taiwan, for academic purposes.

According to the regulation, the exporting seeds and seedlings are strictly classified into two categories, academic and commercial. Those within 1 kg of seeds or within 10 seedlings (or tubers) for each variety or strain are dealt with as academic purposes, while those exceeding the foregoing limited quantities are considered to be an act of commercial export, and therefore should be dealt with according to the regulations.

The summary records of past seven years was given in Table 1.

Table 1. Summary of the Statistics of Incoming and Outgoing Seeds & Seedlings from July 1960 to June 1967.

Years	Incoming			Outgoing		
	Crops	Varieties	Countries	Crops	Varieties	Countries
1961	36	4,584	19	32	359	31
1962	23	878	25	38	1,875	46
1963	12	382	18	21	646	58
1964	18	638	19	36	761	54
1965	15	246	16	34	774	43
1966	16	1,105	16	31	848	48
1967	11	199	9	31	786	46
1968	5	256	12	33	1,369	53

Among the summarized result showed in Table 1. rice, wheat, soybean, flax, jute, kenaf, other fiber crops, medical plants, forage crops, vegetables, fruit tree, ornamental plants etc. were introduced from foreign countries; among them, forage crops occupied the major part. On the other hand, lowland rice, upland rice, corn, soybean, peanut, wheat, millet, sorghum, jute, kenaf, roselle, sugar cane, tea, medical

plants, green manure, forage crops, vegetables, melon, watermelon, papaya, fruit trees, ornamental plants, and trees, were exported to abroad. Among them, rice, soybean, vegetables were the major part, Approximately half of these materials were exported to the African countries.

II. Horticulture

A. Experiments on Fruit Trees

1. Pineapple

(1) *The Identification of Various Types of Smooth Cayenne Pineapples*

Of the 10,000 hectares of pineapples grown in Taiwan, 88% belongs to the Cayenne group which is the principle canning pineapples. Various types however, were mixed and degenerated due to long period of negligence. In order to separate these various types of the Cayenne Pineapples, Fengshan Station has made several surveys, investigations, and comparative studies. Based on those data obtained, the Cayenne group may be separated into four types. (1) The so-called Collar of slips which constitutes 95% of the Cayenne group in Taiwan. It is not a desirable type; (2) The Normal Smooth Cayenne a best type occupying 4.5%; (3) The Sarawak, 0.1%; (4) The Convex-eye, 0.3%. This identification and separation of the Cayenne pineapples laid a foundation further studies toward classification, mass selection, and cultivation of pineapple industry in Taiwan.

(2) *The Establishment of Normal Smooth Cayenne Nursery*

In order to select good type (Normal Smooth Cayenne pineapples) and eliminate had ones, Fengshan Station under the aid of JCRR and in cooperation with The Taiwan Pineapple Corporation, has undertaken the job of mass selection of pineapples since 1950. During the former two years works were based on preliminary selection and the latter three years were final selections. As a result of this selection, 10 hectares of Normal Smooth Cayenne nursery was founded in 1959. Henceforth, this nursery will furnish 300,000 planting materials of Normal Smooth Cayenne pineapples for extension each year. The Normal Smooth Cayenne has less slips, early and more suckers, large fruit, no tumors, high yield (increase the yield up to 25% as compare with the collar of slips) good quality, and high canning ratio. It is recognized as a best type in Taiwan.

(3) *To Standardize the Level of Pineapple Fertilization*

For the lack of standardization of pineapple fertilization, a three essential elements experiment had been run by Fengshan Station in 1950–1954. The optimum proportion of the three essentials (N–P–K) for pineapples, obtained from the experimental data, was 8:2:8:i.e., for one plant of pineapples, 8g. of nitrogen, 2g. of phosphate, and 8g. potassium should be used per year.

(4) *Methods of Promoting Early Sucker Growth*

It is suckers that give ratoon crops, however, Smooth Cayenne pineapple gives suckers so late in South Taiwan, especially summer crops, as to cause alternate fruiting. This problem has challenged the horticulturists for a long time. For years experiments, three effective ways to produce early sucker have been obtained: (1)Using Normal Smooth Cayenne type; (2) Treating the pineapple plant with Calcium Carbide during September and October; (3) 20 days after flowering, keeping 1–3 slips on the plant, picking off the remaining ones.

(5) *Close Planting of Pineapple Increase the Pineapple Yield Obviously*

A close planting field experiment of pineapple had been carried out from 1955 to 1958 in 12 different localities in Taiwan, the density of planting were 25,000, 30,000, 35,000 and 40,000 plants per hectare. From this experiment result it showed that close planting increased the pineapple yield obviously, The closer the density the higher the yield, The plant crop yield of 40,000 plants per hectare was 56 tons which increased 48% as compared with that of 25,000 plants. The farmers usually planted 20,000–25,000 plants per hectare.

(6) *Weed Control with Chemical Herbicides on Pineapple Fields*

This experiment has been carried out from the fall of 1958, for the purpose of understanding the possibility of application with chemical herbicides on pineapple fields. The result showed: (A) The fruit yield of application the chemical herbicide was increased 5–20% than of the non-treated. (B) It seemed to be throughly enough to control weeds on pineapple fields' with dosage of 3–5 kg. per hectare of Simazin every year. (C) It would be the important conditions that applicable rainfall be needed to preserve moderate moisture of soils at the time of spraying herbicides. (D) Application of herbicides has its economical advantage of saving much expenditure of weeds eradication. It also may let us get rid of weeds on right time. That is the key to increase the yields of pineapple.

2. Banana

(1) *The Effect of Potassium on Banana*

This experiment had been carried 1958 in Fengshan Station which have cooperated with Chemical Fertilizer Service of Taiwan. The nitrogen and phosphorate was fixed, but potassium divided into three groups as for 0, 75 and 150g. per plant/per year these result it showed that increased in height of 14.23% and in diameter of 12.94% to promoting early about 1–2 months. Not only may be improved quality but also resistance to diseases. The optimum proportion of nitrogen and potassium was 1:3.

(2) *Studies on The Nitrogen Supplied in Form of Urea upon Banana*

The purpose of this experiment is to study the effectiveness of urea fertilizer on banana plant under the growing conditions with relation to the yield. In order to establish the application on urea at the main banana production regions in South Taiwan and attempted to solve some basic problems on banana culture the result as follows:

(a) The concentration of urea solution at 5% level was proved to be safe to the plants, but under the condition when the banana plant only in 1–2 months, it was better to used 1% instead.

(b) The results indicated that it has no yellowing & wilting from banana plants subjected to foliar sprays of high biuret concentration at 3% level.

(c) The fact that urea is the more effective in banana culture than the ammonium sulphate is established.

(3) *NPK Fertilizing Trial for Banana* (1953–1956)

Potash fertilizers were proved of critical importance in increasing both the quality and yield of banana. Phosphate fertilizers needed more in the plant crop than ratoon one. Over nitrogenous fertilizering caused a treatback in yields. An over-all ratio of the adaptable NPK combination is 1:1:3 under most of the soil of banana plantation.

(4) *Testing of Different Nitrogenous Fertilizers for Banana* (1954–1956)

Urea, and ammonium sulfate were proved as the satisfactory nitrogenous sources of banana.

(5) *Test for the Times of Setting Follower of Banana* (1952–1957)

Selected the suckers peeping out during March to September in a ratoon, a crop in fall-autumn months could be expected and this served vitally in regulating the year-round supplys of export banana.

(6) *Testing the Effect of Soil Reservation Under Fertilizing Condition*

After treatment of soil reservation, terraced plantings were expected to be superior to the slope hillside. This test revealed that the induction was untrue at least in first one to two year. The rearrangement of surface soil, which banana roots were established, played bulk tribute to this effect.

(7) *Close Planting of Banana Increase the Banana Yield Obviously*

This experiment had been carried out by Chiayi Station from 1959 to 1967. The adaptation of planting interval of 8×6 feet revealed the potential yield capacity of banana in central Taiwan and this revolutionized the traditional planting density and gave an increase of yield of 57.09%. In south part of the Island, the closer density of 6×7 feet was recommended.

3. Citrus Fruit

(1) *Varietal Collection and Survey*

According to survey, there are about 14 species and more than 83 varieties in Taiwan. 28 varieties have been collected for fruit quility and quantity improvement during tbe past few years.

(2) *Citrus Mother Tree Selection*

3,959 mother trees of Tankan, Ponkan and sweet oranges have been selected for extension.

(3) *Varietal Selection of Citrus and Protection of Re-selected Mother Trees*

After years of cultivation without adequate work on varietal selection, the fruit characters as well as plant types of the main citrus varieties on this Island are liable to vary within the same varieties. Since desirable mutation characters can be accumulated by chance obtained by certain individual plants, new outstanding varieties or strains may be obtained through selection. The tight-skin type Ponkan is more desirable than the loose-skin type for export, seedless Tankan with hollow core is desirable both for canning and fresh fruit marketing. Our Institute have been undertaking this varietal selection work since 1965. In order to supply better scion from dependable trees to the nurseries for multiplying qualified nursery-trees, the mother tree selection program should be strengthened. The work has been so arranged that agricultural selection of the concerned prefectural governments were

responsible for the preliminary selection work and the work of this Institute to reselect the trees for protection. The mother trees were protected and distributed as follows:

Kind	Sub-total No.	Distribution									
		I-lan	Taipei	Hsin-chu	Tao-yuan	Miaoli	Tai-chung	Chan-ghwa	Chia-yi	Tai-nan	Ping tung
Citrus unshiu	100	100	—	—	—	—	—	—	—	—	—
Fortunella margarita	50	50	—	—	—	—	—	—	—	—	—
C. poonensis	400	—	—	150	—	50	80	50	70	—	—
C. tankan	1,100	200	400	300	100	100	—	—	—	—	—
C. grandis (var. Matou Wen Tan)	100	—	—	—	—	—	—	—	30	70	—
C. grandis (var. Pei-Yu)	70	—	—	—	—	—	—	—	20	50	—
C. sinensi (var. Colden Seal)	100	—	—	—	—	—	50	50	—	—	—
C. limon (var. Eurcka)	50	—	—	—	—	—	—	—	—	—	50
C. limon (var. Lisbon)	30	—	—	—	—	—	—	—	—	—	30
Total	2,000	350	400	450	100	150	130	100	120	120	80

(4) *Citrus Rootstock Trial*

On the basis of the preliminary observation the Tankan on the Canton lemon, Rough lemon and Rangpur lime rootstocks grew much more rapidly than on the Ponki, Hassaku, Cleopatra and Koethen sweet.

(5) *A study on Citrus Grafting*

In the past, leaves of *Langus densispieata* or bamboo were used as wrapping materials and muddy paste was used to cover the grafting. Now plastic strips and covering material have been used instead. The percentage of take have been increased up to 90 percent or more depending on climatic condition following grafting.

(6) *Experiment on Citrus Grafting Using Plant Hormones*

(a) The effect of plant hormones on promotion of citrus grafting:

The experiment was carried out in this Institute from 1962 to 1963. The purpose of this experiment was to promote the ability of callus formation on the part of grafting and to increase the percentage take of citrus graftage by using plant hormone treatments in various parts of the year. The kinds of plant hormones used were B-Indole acetic acid (IA) and B-indolebutyric acid (IB). Both IA and IB were prepared as 50, 100 and 200ppm water solution or 500, 100 and 2,000 ppm lanolin paste. The results were as follows:

Treatments of the water solutions of plant hormones were high in success in each of the grafting took place in every other month. It seemed effective for promoting the percentage take of the graftage especially of those in October and June. There were no big difference between IA and IB, neither among the various concentrations. Treatments in the form of lanolin paste plant hormones were not ideal which was no better for the formation the callus of scion and stock, the percentage take of graft was low than that of check plot.

(b) The effect of plant hormones on callusing of citrus grafting:

This experiment was conducted from 1963 to 1964. The grafting was held in every other month from June 1963 to June 1964. The results may be summarized as follows:

As a whole, grafting in August (using spring buds), December (using first summer buds), February (using second summer buds), and April (using autumn and winter buds) showed strong growth but in the meantime the percentage take of the check was so high that there was little difference between the treatments and the check plot. Grafting in October (using first summer buds) and June (using spring buds) grew weak, but plant hormones stimulated the wound-cell of the part of grafting and increased the percentage of take. The effect of plant hormones varied with different kinds of plant hormones used and in different seasons. In cool season, such as in October, the 50 and 100 ppm NAA were more effective. while in warm season, such as in June the 100 and 200 ppm IB seemed better.

(7) *Effect of Shading on Tankan Tangor (Citrus Tankan Hayata)*

The experiment was conducted from January 1963 to January 1966. The orchard site was chosen in the area near the sea coast of Tamsuei of Taipei Pref. where citrus trees were usually subjected to wind damage. In order to observe the effectiveness of Acacia (*Acacia confusa* Merr.) as a windbreak as well as shading tree for citrus orchard, experiment plots were established in whole Tankan tangor and Acacia were interplanted. The Tankan fruits grown under Acacia trees were outstanding for their smoothness and attractiveness in appearance and the percentage of wind scars on the fruit surface was lower in the shaded plots than those in the plots without shading. The evidence showed that Tankan interplanted with Acacia has improved the fruit qualities and gained the windbreak.

4. Mango

(1) *Testing and Extending American Varieties*

11 propagating gardens were established. And over 200,000 grafted seedling were extended to farmer.

(2) *Grafting Technique Test*

Grafting during warm season and scion treatment made the success of any

grafting easily.

(3) *Study on Storage and Post-harvest Treatment of Mango Fruit*

This study was carried out from July to August in 1964. According to the combination of 4 post-harvest treatments (126° F hot water, Dithane M-22, 1% Dowicide A and Check) and two kinds of storage temperature (42.8°F & 86°F) the result as follows:

(a) Mango fruits under low temperature (42.8°F) could store for 30 days but under room temperature (86°F) could only store for 9 days.

(b) Among the 4 post-harvest treatments the hot water treatment gave very good control of mango anthracnose disease. The other two treatments with fungicide gave no more effect than the check.

(c) The best way to control the anthracnose disease of Mango is to treat the fruits with 126°F hot water for 10 minutes first and then to store them under the low temperature (42.8°F).

(4) *The Success of Introduction of Mangoes*

Fengshan Station and Chia-yi station had been introduced 5 Varieties of Mango from America since 1954 by Joint Commission on Rural Reconstruction, and then among which Haden, Zill and Irwin are the best in yield and quality. Now have been extended in a large areas of South of Taiwan since 1960.

5. Coffee

(1) *Evaluating Imported Arabica Varieties*

The original countries included Philippines, India and Hawaii, HAES 6550 with a leading yield was concluded to be a promising variety.

(2) *Shading and Fertilizing Trial*

Unshading but with suitable fertilizing gave a higher yield, some 50.05 % increase, to coffee culture. The NPK ratio adapted 2:1:4 and 3:1:4. If the culture was under shading condition, nitrogenous fertilizing should be detracted.

6. Other Fruits

(1) *A Study on the Improved Propagation Method of Guava*

The result indicated the plant hormones significantly increased rooting of the guava cuttings, and cutting in spring was more suitable than in fall.

(2) *Sexual Control of Papaya*

Papayas have three fundamental sex forms; male, female and hermaphrodite. Male trees often appearing in high proportion do not bear. Observations on papaya heredity were made in 1950-1951, showing that self-fertilized hermaphrodites always segregate into hermaphrodites and female with a ratio 2:1.

(3) *An Experiment on the Collection of Papain*

This experiment was carried out from Feb. 1957 to Dec. 1958. The purpose was to select some suitable varieties and to get a good method on the collection of papain. Eight varieties were used. Among those varieties the hybrid Fengshan No. 1 was the best one for the collection of papain. It had high fruit yield 60 Kg per year, resistance to root rot. and high latex yield 129 g. per plant/per year.

(4) *Temperate and Tropical Fruits*

The best persimmon variety Tiu-Lon, has been collected and recommended to the fruit growers for cultivation, and a number of good varieties of avocado have been introduced from abroad.

B. Experiments on Vegetable Crops

1. The Preparation and Test of Antiserum to Potato Virus X

The utilization of antiserum has been recognized as an easy and effective method to find latency potato virus X. One hundred and twenty millilitres of antiserum by Bowder and Pirie method was prepared, and its efficiency compared with the products of Japan; the result was satisfactory.

2. Test on the Seed Production of Kinmen Early Kohlrabi

Kinmen kohlrabi is capable of bolting and producing seeds in the plain part of north Taiwan. However, owing to the long rainy season in spring, the seed production work does not so ideal, and the quality of seeds which are produced in the paddy fields of poor drainage is especially low. We find that the Hsi-pao Farm (altitude 1,020m) and Fu-Shou-Shan Farm (altitude 2,248m) are the ideal localities for seed production. In order to increase the yield of seeds and avoid rainy season begining from June, it is suggested to plant as early as possible in these localities.

3. Studies on Chemical Regulation upon Vegetable Crops

On the basis of technical or economical demand, we often face the necessity to regulate the physiological phenomena of plants. Utilization of chemical substances has been more and more recognized as one of effective ways to treat this problem especially after the World War II. For more than one decade, our staffs have used several kinds of chemical substance such as plant hormones, gibberellin, and plant growth retardants etc. to study the problems of induction of parthenocarpy, growth or dormancy regulation. Now we introduce the outlines of some important works conducted in the last three years as follows:

(1) *Dormancy Breaking of Seed Potatoes for Spring Planting*:

We investigated that the effects of single or combined application of gibberellin and ammonium thiocyanate. Soaking the dormant seed potatoes in the solution containing 2% ammonium thiocyanate and 5 ppm of gibberellin concentration for 30-60 minutes prior to the "bud forcing procedure" showed the best results. This method has advantages of easy handling, high dormancy breaking, producing, thick and faster grow, and high yields.

(2) *Breaking of Seed Dormancy of Brassica Juncea Var. Megarrhiza*

The newly harvested seeds of *Brassica juncea* var. *megarrhiza* usually enter the dormant stage under high temperature. Then we can not expect the germination of such seeds during the dormant stage unless we use artificial methods, and the low temperature treatment (10°C and 15°C) and gibberellin treatment (50-200 ppm) showed excellent results on breaking dormancy of the seeds. The effects of other chemicals such as thiourea, potassium nitrate, ammonium thiocyanate, and

two commercial plant growth stimulants Atonik and Bene Plant were inferior, but 2,000 ppm thiourea treatment was rather satisfactory.

(3) *Study on the Plant Growth Retardants upon Growth of Vegetable Crops*

We have tested two kinds of plant growth retardant, (2-chloroethyl) trimethyl-ammonium chloride (CCC) and *N*-dimethylamino succinamic acid (B995) on cucumber and radish. The results on cucumber showed that plant growth retardants produced compact and dark green colored plants; lowered the position of the first pistillate flower formation; promote the first pistillate flowers; increased the position of the first tendril formation. On the yields of treated plants, showed rather variable, but tendency to increase both total weight and number of fruits was observed. The results of our preliminary experiments on radish (cultivated in the clay pots) showed that the root weight and total sugar contents in roots of treated plants were larger than those of untreated plants. We also observed the growth promotion effects of top parts of treated plants in the later period although in the earlier stage a retarding effect was found.

4. Breeding of Cauliflower

"Fengshan Extra Early", "Fengshan Early", "Fengshan Medium" and "Fengshan Late" were bred at Fengshan Station. These four varieties have become as the commercial ones. At present, Fengshan Station is carrying out the breeding work of hybrid variety.

5. Breeding of Tomatoes

"Fengshan hybrid No.1" and "Fengshan hybrid No. 10" were selected for local market, while "Fengshan hybrid No.3" and "Fengshan hybrid No. 17" were selected for both shipping and local market.

6. Breeding of Watermelons

"Fu-kuang" hybrid, "Fu-Pao" hybrid, "Shao-Feng" hybrid and "Fengshan No.1, No. 3 Triploid Seedless" watermelons were bred by Fengshan Station, and have become the main commercial varieties of watermelon in Taiwan.

7. Introduction of Other Vegetable Crops

(1) *Onions:* "San Joaquin Yellow Globe" was picked out and has been extended.

(2) *Asparagus Lettuce:* "Celtuce" was picked out and successfully extended in Taiwan.

(3) *Cabbage:* Superior early maturing varieties such as "Copenhagen Market" "Ginriki", Superior mid-season varieties such as "Sakata Early Mid-Season", "kuroba Riso" etc., Late maturing and good shipping varieties such as "Nagaoka Shikitori", "Kuoetsu", "Wakatake", "Nagaoka Ideal", "Matsukaze", "Umewaka", "Hyogo No.3", "S.S. Cross", "K.Y. Cross" have been picked out.

(4) *Chinese Cabbage*: "Nagaoka Hybrid Ideal" with superior quality, good shipping and resistant to soft rot was selected and extended. This variety has been very popular with Taiwan Farmers.

(5) *Watermelon*: "Sugar Baby" was picked out and turned out to be a superior commercial variety.

(6) *Sweet Pepper*: "California Wonder" was picked out for its good shipping quality and turned out to be a good commercial variety.

(7) *Broccoli:* "Early One", "Texas 107", "Early Green Italian", "Grand Central-1" were picked out.

8. Segregation and Selection of Vegetable Varieties

(1) *Pe-tsai*: To purify "Fengshan Pe-Tsai" (tolerant to hot weather) as the main Pe-tsai in summer season. To purify "Edible Yu-Tsai" (late variety) and export the seeds to the South East Asia.

(2) *Chinese Kale*: To purify "White Flower Chinese Kale" and export the seeds to South East Asia.

(3) *Sweet Pepper*: To purify "Ruby King" as the leading variety of Taiwan.

(4) *Garlic*: Two superior varieties, "Fengshan Selected No.1, and No.2", were selected and being propagated.

(5) *Edible Soy Bean*: To purify "Fengshan Green Early" and extend as a commercial variety.

9. To Hasten the Setting Period of Onion Seedlings

Previously the vegetable growers in Taiwan set the seedlings of 50-60 days, according to our experimental results, the seedlings grown in the seed bed of 30-40 days were suitable to setting. The later the setting, the more difficult the recovery of growth vigor, the later maturing date, the higher percentage of bulb division and the lower yield.

10. Test on Sowing of Onions

(1) The optimum sowing season of Early Grano, Excel Bermuda, San Joaquin, Granex etc, was from the middle of August to the middle of October. During this period, the earlier sowing we did, the larger bulb and the higher percentage of splitting bulbs we obtained.

(2) Early sowing was usually hard to succeed due to typhoon, high temperature and heavy rainfall. The seed bed should be protected carefully. The later sowing we did, the higher percentage of established seedling we got.

(3) The optimum sowing time of Red Creole was from the end of September to the beginning of October, Early sowing was easy to form bolting.

11. Deciding the Standard Planting Distance of Onions

From the experimental results, the standard level of planting distance: Distance between the row of 20 cm., spacing in the row of 10 cm., 384,000 plants per hectare. can be planted. If the farmers planted the seedlings by large distance, not only the yield of per unit area would be decreased, but also the amounts of medium sized onion bulbs would be diminished, meanwhile the percentage of bulb-division would be increased too.

12. To Investigate the Promoting Production Factors of Potatoes

From the experimental results, the size of seed pieces, the planting distance and the amounts of fertilizers application are the more important promoting production factors. Under the short day of Taiwan the suitable distance between rows

is 65 cm., spacing in the row is 20cm., the weight of seed pieces is 20g., the application of compost or animal manure, is 24,000 kg.,in addition to chemical fertilizers: nitrogen 160kgs, phosphate 144kg., potash 180kg. per hectare.

13. Influencing Factors on the Fruit Quality of Triploid Watermelons

(1) The presence of colored seeds and large white seeds were greatly attributed to the different combinations between the tetraploids and diploids. Fengshan No. 1 triploid watermelon has less colored seeds and smaller white seeds than Fengshan No. 5 variety. Moreover, the fruits formed on the first female flowers were usually become more frequent if the seed watermelon used as the pollinator.

(2) Thick rind fruits were greatly attributed to the relation between variety and soil. Besides, the fruits of incomplete pollination, the first fruits of the vines were inclined to become thick rind.

(3) Triangular fruits or misshapened fruits were usually produced due to the incomplete pollination.

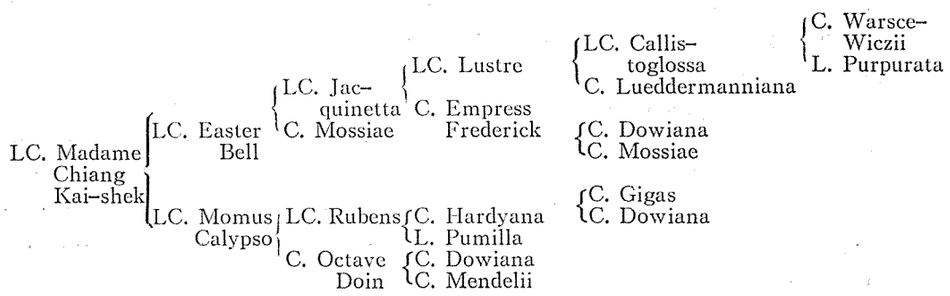
C. Experiment on Flowers

1. Experiment on Cross Breeding of Orchid

The purpose of the experiment is to develop new crosses or lines of fine characteristics for future extension as a foundation of a new orchid industry in Taiwan. The objectives for the improvement are to obtain round sepal, petal, lip, a short throat with a general round shape of the flower, deep color and longer persistance of the flower.

The experiment has been conducted since 1946. Up to the present time 836 sets of crosses has been performed and 199 crosses of seeds has been sown with the success of 117 new crosses germenated. Among these, 10 new Cattleya, 50 Dendrobium, 4 Phalaenopsis, 1 Vanda, 1 Oncidium and 66 others have come into bloom.

The most excellent cross in this experiment seems to be the variety LC Madame Chiang Kai-shek which has won the first prize from the international flower exhibition in California U.S.A. 1953 and many prizes in other international flower show. Its genealogy table is as follows:



2. Improving Experiment on Various Kind of Flowers

The purpose of the experiment is to improve the quality of flowers. The following materials are used:

(1) Annuals: Such as Marigold, Balsam, Pansy, Cosmos, etc.
(2) Perennials: such as Chrysanthemum, Verbena, Gerbera, etc.
(3) Bulbs: such as Dahlia, Clivia, Amaryllis, Lily, Gladiolus, Gloxinia, Daffodil, etc.
(4) Shrubs: Rhododendron, Camellia, Hibiscus, Arabian jasmie, etc.

Method of experiment:

(1) Introduction and acclimatization.
(2) Hybridization method of breeding.
(3) Induction and mutation method of breeding.

Result of experiment:

This experiment has been conducted since 1950. The work of introduction and acclimatization of flower has been done on more than two hundred kinds of annuals, perennials, and bulbs. The introduced varieties were carefully treated to study their suitability for the climate and soil of Taiwan. After observation these two hundred and more kinds of the best and newest varieties were kept for further breeding.

III. Agricultural Chemistry

A. Soil Survey (General Survey of Soil)

A province-wide soil survey was launched in 1946. The field work was finished in 1953. A general soil report with a soil map of a scale of 1:500,000 and the semi-detailed reports along with 1:100,000 soil maps consisting of 12 prefectures of Taichung, Nantou, Changhwa, Tainan, Yunlin, Chiayi, Penghu, Kaohiung Pingtung, Touyuan Miaoli, and Hsinchu were published.

Among the mountains, rolling hills, terrace table lands, and coastal plains, under the tropical dry humid to microthermal perhumid (Thornthwaite's System) climate and mostly on the sedimentary rocks partly igneous rocks, fifteen great soil groups have been found. The lithosols occupy the largest area and occur on regions of higher altitude. The alluvial soils are ranking the second in area, and are the most important agriculture soils. They are developing on coastal plains and may be classified into three categories: those developed from slates, from sandstones and shales and from schists. The reddish brown latosols are developing mostly on the terrace table lands less than 500 M. in elevation. The yellowish brown latosols and the red-yellow podzolic soils are occuring on the lower parts of rolling hills below the elevation of 1,000 M. and 1,600M. respectively. In the regions of higher altitudes (3,500-500M.) of central mountain system, where climate is moist and cold, and vegetations change from deciduous to coniferous, the gray brown podzolic soils, brown podzolic soils and podzols are developing. The soils minor in extent are brown forest soils under deciduous forest, rendzina from coral limestone, dark volcanic ash soils on hills, regosols by the sea coast, meadow soils, planosol-like soils and saline soils on the hill side, central plain and southern part of the coastal plain respectively.

B. Land-use Capability Survey of Marginal Zone between Forest Land and Crop Land in Taiwan

By the technical and financial assistances from Joint Commission on Rural Reconstruction, our Institute conducted this survey started in 1953.

The so called "Marginal Zone" is arbitrarily applied to the rolling and hilly zone of land lying between the lowland plain and the forest high mountains below 1,000M. in altitude.

The purposes of the survey are to obtain data on land conditions, to classify each mappable unit of the land according to its land-use capability, and to provide a scientific basis for future land-use.

The American system of land classifications through a minor modification was introduced into this survey, and lands are classified into four classes of paddy field and eight classes of dry land based on land slope, soil erosion and essential soil characteristics e.g. depth,permeability, texture and natural hazards. Present land use is also put on the maps. By using aerial mosaic, land-use capability maps of a scale of 1:20,000 were produced.

The field work was finished by the end of 1958 and 183 sheets of land-use capability map were printed in 1960.

The land capability classes and their existing land uses of the 15,000 sq KM of surveyed land are summarized as follows:

Table of Land Resource and Existing Land Use of Marginal Zone between Forest and Crop Land in Taiwan

Existing land use	Paddy field				Dry land		
	PI	PII	PIII	PIV	I	II	III
Paddy rice	7,665.0	35,729.1	67,866.6	69,780.8		154.2	34.8
Upland crop		14.8	324.8	340.9	330.8	18,448.2	51,442.1
Horticulture crop		1.2	155.9			476.7	1,007.2
Forest			3.1			97.2	1,840.0
Grass or Idle land			50.8	8.4		162.8	1,339.2
Village and Cemetery	176.0	1,572.2	1,054.1	287.2	105.2	1,976.8	4,114.9
Grazing land	1.2						46.8
River bed							
Total ha	7,842.2	37,317.3	69,455.3	70,417.3	436.0	21,315.9	59,825.0
Total %	0.52	2.49	4.64	4.70	0.03	1.42	3.99

Existing land use	Dry land					Total area (ha)	%
	IV	V	VI	VII	VIII		
Paddy rice	51.6	9.2	38.8	1.6		181,331.7	12.11
Upland crop	29,809.0	17,461.7	34,809.7	114,685.5	147.0	267,814.5	17.88
Horticulture crop	886.2	567.3	4,783.4	25,510.9		33,388.8	2.23
Forest	2,950.6	2,222.5	22,007.8	724,312.3	8,097.9	761,531.4	50.84
Grass or Idle land	2,359.8	2,937.4	13,410.5	123,449.6	18,122.0	161,840.5	10.80
Village and Cemetery	1,917.2	1,470.0	2,454.4	2,168.0	105.6	17,401.6	1.16
Grazing land			16.0	34.8		98.8	0.01
River bed					74,477.7	7,447.7	4.97
Total ha	37,974.4	24,668.1	77,520.6	990,162,7	100,950.2	1,497,885.0	
Total %	2.54	1.65	5.18	66.10	6.74		

C. Fertilizer Researches

The problems of fertilizer have been approached from the practical point of views. It employs the field experiment as a main tool, and statistical analysis as well as chemical analysis is more frequently called upon for the interpretation of its result. The ultimate aim consists in more yield, better quality with a minimum of fertilizer application. Among those experiments conducted since the restoration of Taiwan, especially in recent 10 years, the followings are of most importance.

1. A Study on the Application of Calcium Cyanamide for Rice

Calcium Cyanamide is one of the main productions of nitrogenous fertilizer in Taiwan. However, farmers are not well acquainted with it, and the misuse sometimes leads to crop failure. Experiments were conducted in order to determine the rate of decomposition of calcium cyanamide and to ascertain the toxic substance developing in the soil, in which cyanamide appears to be the only substance responsible for crop damage and the best method of application is to apply the calcium cyanamide as base manure a week before the transplantation of rice plants. Demonstration on the application of calcium cyanamide was made at 267 localities to give the farmers more information and to lead them to the most effective use of it.

2. Experiments on the N-P-K Requirements for the Main Crops of Taiwan

The kinds of crop have been tested for their optimum fertilizer requirement at 27 localities. Reports concerning sweet potato, wheat, jute, peanut, hemp, cotton, pineapples, bananas, citronella, and soybeans wers published.

3. A Study on the Relative Availability of Ammonium Sulphate, Ammonium Chloride, Calcium Ammonium Nitrate and Urea to Rice

The experiment was conducted in ten localities for three years in order to study the relative effectiveness of these fertilizers for rice. According to the results, ammonium chloride and urea appears to be slightly less effective as compared with ammonium sulphate, and calcium ammonium nitrate was found to be somewhat inadequate in paddy soils

4. A Study on the Tungshan Paddy Soil

A characteristic crop damage prevails in Tungshan paddy soil, of which the actual cause had long been in mystery. It was revealed from this investigation, through extensive field survey along with soil and plant analysis, that too much Fe^{++} and possibly Mn^{++} developed under poor drainage were responsible for the crop damage. Some possible practices of reclamation were also submitted.

5. A Study on the Method of Application of Urea on Rice

It was intended in this experiment that the influence of time of irrigation, placement of urea and time of top dressing are to be brought to light. The experiment was conducted during 1955–1957 in seven localities. The results revealed that most of the urea applied in the soils of the experimental localities decompose whithin 3 to 5 days, and evaporation of ammonia by the application of urea is very significant as compared with that of ammonium sulphate. In general, deep placement and top dressing was found significant to increase the yield of rice.

In addition to these experiments as stated above, other kinds of research works, such as; Demonstration of green manure for rice; Study on the effect of trace elements on plant growth; Study on the proper combination of organic and inorganic nitrogen on paddy were also carried out.

6. Studies on the Effect of Silica on Paddy Rice

In this study, evaluation was made on the rice response to silicate fertilizer in Taiwan soils.

The field experiments showed some soils were responsive to the application of silicate slag, while others did not. The soils responding to silica are the acid sandstone and shale alluvial soil of Taipei, the latosol of Taoyuan and the ill-drained paddy soil of Ilan. The increase of paddy yield was 9% on average. The effect was particularly significant where rice blast occurred.

The result of pot experiment showed that the effectiveness of silica was resulted from the increase in average weight per panicle rather than the number of panicles per hill.

The silica content (SiO_2) of the straw at harvest varied from 5 to 14% among different localities, which reveals considerable difference in silica supplying power among the various kinds of soil. In general, the SiO_2 content of the straw from those localities where silica was effective are low(5.5–9.0%) as compared with that from the other localities (9.5–14.0%) .The SiO_2 content of straw and the response of paddy to silica application are significantly correlated.

The content of soluble silica in acid sandstone, shale alluvial soil and latosol was found very low as compared with that in slate alluvial soils, saline soil and schist alluvial soil. The soluble silica content of soil seems to be somewhat related with the soil reaction.

D. Plant Nutrition

1. Studies on Nutrient Absorption of Rice Plants in Taiwan

Inorganic nutrient absorption by rice plants under different fertilization, temperatures, soil conditions and varieties has been investigated. The purpose of the study is to investigate the basic information of various nutrient status of rice plants and to find out how to use this information for efficient fertilization and crop production.

The results obtained were as follows. The high temperatures increased nutrient absorption and plant weights, but it didn't always result in an increase of grain yield. The plants under high temperatures might tend to reinforce vegetative growth at the cost of reducing grain production. Nutrient absorption by rice varied greatly with different varieties. It was observed that some native varieties had higher NPK contents than Japonica varieties had. The high yielding varieties generally absorbed greater amounts of NPK per ha as well as per ton of grain produced. significant varietal differences of response to fertilizers were also observed. Kinds of soils gave stinctly different characters on plant growth. Plant length was longer and tiller number was less in Pingtung slate alluvial soil than in Taipei sandstone & shale alluvial soil. Plants grown in Pingtung soil had more absorption of K, Si, Mn and less of N, P and Fe than in Taipei soil. It indicated that Taipei soil was deficient in available Si and Mn. Field investigation of nutrient absorption by rice in two crop seasons were conducted at various paddy soils. Yields of the first crop were generally higher than that of the second crop, consequently, more nutrients were absorbed by plants in the first crop. It was found that the N content of straw was lower and the K content was higher in the first crop than in the second crop. Many different nutritional characters were found in plants grown in the two crop seasons.

Three research projects are now in progress.

(1) Study on the nutrient absorption by rice plants as related to nitrogen fertilization.

(2) Study on relationship between fertilizer responses and nutriotinal and agronomic characters of rice varieties.

(3) Comparative study on nutrio-physiology of rice plants grown with solution culture in the first and second crop seasons.

2. Lysimeter Experiment on Paddy Soils

A lysimeter experiment has been carried out in order to examine the leaching loss of nutrients in different paddy soils of Taiwan and nutrient uptake by rice plants. A comparison on the effect of ammonium sulfate and urea on paddy rice and leaching loss of plant nutrients in paddy soils was investigated. The leaching rate of nitrogen fertilizers was found as 6.3% in the ammonium sulfate plot and 6.2% in the urea plot. The absorption rate of fertilizers by rice plants was found as 38% in the ammonium sulfate plot and 33% in the urea plot. The average of leaching loss of plant nutrients in one crop season were as follows; Ca 213 kg/ha, Mg 76 kg/ha, K 22 kg/ha, N 13 kg/ha, P 0.7 kg/ha.

A lysimeter experiment of the effect of compost application on rice and leaching loss of plant nutrients in paddy soils is now under way.

3. Study on the Growth of Rice Plants in Ill-Drained Paddy Soils

The purpose of this study is to clarify the actual cause of the occurrence of physiological disease of rice in ill-drained paddy soils and to find out some effective methods for soil improvement and crop production.

Nutritional characters of rice plants in ill-drained paddy soils as well as some chemical properties of the problematic soils have been investigated. The injured rice plants grown in the soils in Ilan prefecture display very poor growth of straw as well as of roots with symptoms characterized by brown spots on leaves. It was suspected that the toxicity of such soils is mainly due to some reduction products of which sulfide and ferrous iron are probably the most important. However, recent pot experiments revealed that the application of iron hydrooxide as well as manganese dioxide could prevent the damage of plants under serious organic matter decomposition in the problematic soil. Studies are needed to greater extent for improvement of rice culture in those ill-drained soils.

4. Studies on Plant Analysis as a Guide for Crop Fertilization

A great number of plant samples have been analyzed in the Laboratory of Plant Nutrition. Leaf analysis of citrus plants was made for diagnosing nutritional status. Generally, analytical results of plants show that the concentration of nutrients of the plants are closely reflected by fertilization of those nutrients to the soils. The problem of learning what concentration is necessary for plant growth must be solved for present by trials.

E. Soil Fertility

1. Soil Tests for Crop-land of Taiwan

To provide fundamental information needed in developing reasonable fertilization

on crop-land soils, detailed survey on the status of soil fertilities of the soils has been conducted since 1959. Up to present, more than 80,000 samples of surface soils covering an acreage of about 800,000 hectares of arable lands are analyzed on their available nutrients and related properties. The whole work had been finished in 1968.

2. Calibration Study on Soil Tests

Basing on the results of the soil testing, soils with different levels of fertility are selected for the study. This study aims to clarify the correlation between the soil P,K tests and the response of rice to P,K fertilizers. Results obtained from the experiments showed that the significant response of rice to P,K fertilization with soil containing Bray P less than 10 p.p.m. and Mehlich K less than 35 p.p.m..

3. Study on Increasing Rice Production of Newly Converted Paddy

About 6,000 hectares of dry land in Shihmen irrigation area will be converted to paddy land after completion of the Shihmen Dam. A critical study on the problem of low rice yield on newly converted paddy soils was conducted since 1964. The results of soil tests and field experiments showed that the soils are extremely deficient in available P. It is further confirmed by numerous field trials that increasing rice production from 2,000 kg/ha to 4,000 kg/ha will be obtained through application of sufficient superphosphate i.e., 100kg/ha or 80kg/ha of P_2O_5 in addition with N and K fertilizers.

4. Soil Tests Carried Out in 1950

2,500 soil samples were collected throughout Taiwan to analyze for pH value, organic matter content, total nitrogen content, available phosphorus and potassium and soil texture. General information of soil fertility of Taiwan was obtained from the results.

5. Field Experiments on N-P-K Requirement for Rice

In 1949 and 1950, forty one N.P.K. fertilizer experiments of rice in $2\times2\times2$ design were conducted on three main groups of agricultural soils of Taiwan at fifteen localities for the study of fertilizer requirement of rice in Taiwan:

(1) Rice responds to nitrogen in all the expreiments on all the soil groups. The tendency is more aparent for the first crop and on the fertile soil

(2) Most Taiwan soils under the present system of manuring condition are not deficient in phosphorus. The deficiency occurs only very occassionally on the lateritic soils.

(3) The deficiency of potash are considerably popular in Taiwan particularly for the second crop and on the acid alluvial and lateritic soils.

In 1953 to 1955, 281 N. P. K. fertilizer experiments of rice in 3^3 confounding design were conducted at the different localities throughout the whole island for the study of soil fertility of the paddy field. The results are summarized as follows:

(1) In Taiwan, the rice responds to the nitrogenous fertilizers popularly and effectively, and its moderats rate of application ranged in 100-120 kgs in first crop and 80-100 kgs in second crop per hectare respectively. The responses of rice to nitrogen on sandstone and shale alluvial soils and on the slate alluvial soils are always more significant than on the red earths.

(2) The response of rice to phosphorus have some effects on red earth, yellow earth and slate alluvial soil when its applied rate below 60 kgs per hectare.

(3) The response of rice to potash is significant in red earths, northern alluvial soils of sandstone and shale materials and partly in slate alluvial soil, especially in second crop, and the rate of application also limitted at 60 kgs per hectare.

F. Soil Physics

Owing to social and economical pressure for more cropland, shifting cultivation on hilly lands and utilization of low productive land has been rapidly increased in Taiwan.

To control soil erosion of cultivated hilly lands and to improve soil conditions of low productive land for more production and safty land use, research work on the related physical properties of the soils has been initiated recently since 1966.

The following research is emphasized at present:

1. Study on Erodibities of Soils on Hilly Lands in Taiwan

Field observation and laboratory study on soil properties affecting erodibilities of several kinds of the soils were carried out. In this study, both infiltration capacity and aggregate stability of the soils are used as an indication of their erodibilities. As a result, the contents of clay as well as organic matter in soils are found as most significant factors affecting soil erodibility.

Study on the relative erodibility of different soils is now in progress by analyzing related properties of more than 400 soil samples from about 150 soil profiles. The result will show the relationship of different kinds of soils to their erodibility.

2. Study on Moisture Retension of Taiwan Soils

For the study of moisture retension of sandy soils, sands derived from different materials, sand stones and slates, were used. The effects of shape, particle size of sand grains as well as contents of silt and clay in the soils on moisture constants and capillary rise of soil moisture have been brought to light.

Effect of soil aggregates on moisture retention of medium textured soils are to be studied.

G. Soil Chemistry

1. Study on Soil Development of Reddish Brown Lateritic Soils in Penghu Hsien, Taiwan

Huayu clay, a reddish brown lateritic soil in Penghu Prefecture, Taiwan was studied clay mineralogically using soil samples taken from five layers of the original soil monolith. The minerals in clay fractions were determined quantitatively by means of X-ray photography, differential thermal analysis, thermal gravimetric analysis, cation exchange capacity, free iron oxide and potassium contents.

Kaolinite identified in the clay fractions accounted for about 60%, muscovite 19–25%, and Fe_2O_3 9–11.5% in all layers of the profile. Gibbsite was also found to be contained 3% in the first and second layers. According to Barshad's method of soil horizon, the five layers of the profile are recognized as accumulation horizon for the first and second layers, decomposed horizon for the third and forth layers and C horizon for the fifth layer based on the analytical results. Consequently, the five layers may be arranged in the order as B_2, B_1, A_{12}, A_{11} and C that coincide with Harrassowitz's theory of the strata of typical laterite. It was concluded that the Huayu clay should be classified as a well developed reddish brown lateritic soil.

2. Comprehensive Study on the Genesis of Reddish Brown Latosols in Taiwan

Studies on the formation of reddish brown latosols and soil surveys that had been carried out in past years in Taiwan were evaluated and thoroughly discussed. Characteristics of reddish brown latosols were described from their physical, chemical and mineralogical properties.

Thirty-nine soil series of reddish brown latosols have been found on the whole island according to the soil classification system of U. S. D. A.. Fifteen soil profiles of representative reddish brown latosols in Taiwan were studied in detail and some podzolization in addition to laterization was recognized in weathering processes of these soils. It was suggested that most of these soil series should be classified as red-yellow podzolic soils or podzolic reddish brown latosols rather than reddish brown latosols.

H. Soil Microbiology

1. Study on Nodule Bacteria of Leguminouns Plants

In order to supply effective nodule bacteria inoculants for the cultivation of green manure and forage leguminous crops, some highly effective strains of nodule bacteria have heen isolated from several kinds of host plants as the results of studies on morphology, cultural character, physiology and nodule forming ability of the bacteria and numerous field experiments. Research on the improvement of powder form inoculants for inoculation practice is now in progress.

2. Study on Reducing Bacteria in the Sick Soils of Paddy Fields

To study the influence of reducing bacteria on the suffocating disease of paddy rice, several kinds of healthy and sick soils are incubated with different treatment and temperature under flooding condition. Changes in Eh and pH values of the soils and amounts of H_2S and volatile organic acid produced during the incubation were determined. The results showed that Eh values of the sick soils were considerably reduced and much more H_2S and volatile organic acids were produced from the soils, which resulted from the highly activities of reducing bacteria in the sick soils.

I. Chemistry of Agricultural Products

In the half preceding ten years, two principal projects were conducted in addition to the routine analytical works in this laboratory. One of the projects was "Studies on the dehydration of green vegetables" and the other was "Studies on the sources of protein feedstuffs in Taiwan".

In the former, a hot air drying method accompanied with sulfite blanching was found to be the best. The optimal condition was blanching with a cold 0.2 per cent sodium bisufite solution for three minutes and drying with a hot air (60–70° C.) for about four hours.

By this method it was found that the enzymes, catalase and peroxidase, were com pletely destroyed during the blanching, therefore, little vitamin C and chlorophyll were lost.

In the latter, for securing supplementary feedstuffs for hogs, studies were made on the main kinds of green manure seeds in Taiwan. The results of studies showed that most of the seeds contained toxicants, such as alkaloids and toxic amino acids, so they could not be readily used as feeds. When properly treated, the seeds of following legumen were usable as feedstuffs; yellow lupine (Lupinus luteus), horse tamarind (Leucaena glauca) and velvet bean (Mucuna capitata) etc., therefore, supplementary feeds can be obtained economically by simple treatment on such cheap seeds merely with acid or alkali solution.

The protein contents of these products ranged from 24 to 35 percent, and no unfavorable effects were observed in the feeding experiments on hogs with the processed lupine and horse tamarind seeds.

In these late ten years, a project titled as "A chemical survey on the nutritive constituents of the main crops in Taiwan" has been carried out. The members of variety used in this survey were calculated as 155, consist of rice:75, wheat:7, millet: 9, other cereals: 12, soybean:15, pea:11, ground nut:17 and other beans:9 varieties. The mean protein content (N×6.25) of each of the crops was found as: rice 9.4 percent, wheat 15.4 percent, pea 29 percent and soy bean 44 percent on oven dry basis, respectively.

Among these crops, the paddy rice was dealt in detail. With the brown rice produced in 1946–1965, the contents of principal nutritive constituents were found being in the neighbourhood of 10g (Ponlai) to 11g (native) with protein, 1.5g with ash, 25mg with Ca, 350mg with P, 250mg with K and 2mg with Fe, in 100g dry matter.

It was also found that the native variety was more rich in protein than the Ponlai variety and the protein content of second crop was superior to that of first crop both with Ponlai and native varieties.

In addition to the chemistry of agricultural products mentioned above, Fengshan Station has also been devoting to study the processing of horticultural products as follows:

1. Foundation of Food Dehydration Industry was Laid

To meet the natoional demand for developing food dehydration industry, investigating and designing of dehydrater was initiated in 1952. Experiments on the dehydration of sweet potatoes, vegetables and fruits were also carried out. In 1953, a two stage tunnel type dehydrater was built up by difficulty-overcoming efforts with a capacity of dehydrating 4—5 tons raw materials daily. It was proved and recognized to be a dehydrater of good characters. In 1954, under the aid of J.C.R.R. and in cooperation with Tainan Farmers Association, a sweet potato dehydrating plant was built at Yung-Kang, which is now under operation.

2. Processing of Canned Fruit Cocktail

There are many kinds of fruits produced in Taiwan. but most of them are scarcely sufficient for large scale canning purpose every year except pineapple and mandarin citrus, the principal products. For this reasion, it is necessary to study the canning of pineapple with other fruits to make a mixture in medium sirup under the name of

canned fruit cocktail for export purpose. Experiment has been done in 1963 and the results may be summarized as follows:(I)Among the many kinds of fruits available for canning, Smooth Cayenne is the best variety of most commonly used, the Solo No. 1 or No.9 of the papaya, the Fu Yen Chung of longan, and the Irwin or Hayden of mango are also among the good varieties for processing of canned fruit cocktail. (2) the operation procedure for canning are fruits peeling, coring, cutting or dicing, trimming, siruping, exhausting, sealing, processing, and cooling. (3)After the canned fruits had been stored for 3 months, inspection and organoleptical tests were performed. Lot 3 (the mixed ratio were pineapple 33%, papaya 33%, longan 17%, mango 16% with a few grains of cherry) is the best, having attractive color, fine texture and pleasing flavor. (4) The enamel lined cans should be used to ensure the retention of the natural color of canned fruits.

3. Dehydration of Onions

Onions can be utilized to dehydrate to dry form or even to onion powder, for good selling in the international market. Onions used for dehydration must be the varieties that can keep the white color and pungency taste after dehydration. This Experiment Station introduced through J. C. R. R. thirty varieties of onions from United States. These varieties were planted in our vegetable garden. After harvested, a part of them was used for dehydration by means of Cabinet hot air drying method. Summary of the study of dehydration of onions that was dealed with in 1965 shown below:(1) Variety Tropicana is the highest in drying ratio in reaching 15.7%, followed is Hybrid No. 8, 13.2%. In comparsion with color and pungency flavor, both the Hybrid No. 8 and Hybrid No.4 are the best, followed is Joure Paille des Verties. Although the drying ratio of Tropicana is the highest among the thirty varieties, but it is inferior in color and pungency taste to the above three varieties. (2) The pungency taste of onion is due to the enzymic action. No blanching is necessary that is similiar to garlic.(3) the slicing operation should be done in a forced ventilization room in order to avoid the atmosphere contamination. (4)A two stage tunnel type dehydrater can be used with large quantity is to be operated. In parallel-flow current tunnel, the dehydrating temperature should be kept to 180—190°F, and the counter-current tunnel was 140° to 150°F, until the moisture content of the product is reached 6 to 7%. (5) Both So_2 and $NaHSO_3$ can damage the color and flavor. No sulfuring is needed. (6)The dehydrated onion has the hygroscopic character. The keeping quality will be damaged when it was exposed in air. Tin can storage is suggested. The product is very easy to break when handling. Careful and rapid treating is necessary.

4. Dehydration of Sweet and Hot Peppers

The Variety Rubyking of sweet pepper was used as the raw materials for dehydration, they have the thick-walled concial and smooth fruit. The varieties Choutien and Thailand of hot peppers appeared to be suitable for drying in ripe red state. The pepper fruits are thoroughly washed and stems, cores, interlocular paritions removed. The peppers were then cut in dices and the thickness of ovary wall. Peppers were not peeled but should be kept clean. Blanching was in flowing steam for 4 to 6 minutes. Traying

of the blanched material was 1 to 1.5 lb per sq. ft. of drying area. The Cabinet dehydrater was used for dehydration. Initial temperature was about 165 to 170°F and then dreduced to 145—150°F until about one half of the water has been removed. The peppers may darken if the humidity was too high during dehydration and therefore we did not recirculate the air. The dried product of sweet pepper have good green color and sweet flavor but the hot pepper dried product give bright red color and pungent flavor.

5. *Quantitative Analysis of Vitamin C Containing in Fruits*

Vitamin assay of some main tropical fruits in Taiwan has been carried out from 1957—1959. We have analyzed 7 varieties of pineapple, 14 varieties of mango, 14 varieties of guava, 6 varieties of avocado, 6 varieties of orange, 4 varieties of fig and 10 varieties of tomato. Among these seven kinds of fruit the highest vitamin C content was guava in which contained 247—316 mg. per 100 grams of flesh. The vitamin content of the other fruits were: Mango 56—123mg., avocado 63—74mg., pineapple 52—60mg., orange 43—51mg., fig 24—27mg., and tomato 17—29mg.

6. *Miscellaneous Works on Processing*

(1) *Pineapple*: Canning experiments on pineapple with different variety and various cultivating conditions. Experiment on the change of ascorbic acid and sugars in pineapple during ripening period. Experiments on the manufacturing of pineapple candy and pineapple jam. Experiment on Bromelin (an enzyme of pineapple) extraction from pineapple fruit. Experiment on the dehydration of pineapple.

(2) *Papaya*: Experiment on canning papaya. experiments on making papaya juice and jam. Experiment on manufacturing papaya preserves. Separation of the crude papain (an enzyme of papaya) and determination of proteolytic activity of crude papain.

(3) *Banana*: Experiment on the manufacturing of banana puree. Experiment on the variation of chemical composition of banana during the different harvesting periods.

(4) *Longan*: Experiment on canning longan fruits. Experiment on manufacturing of longan jelly and longan jam. Experiment on the dehydration of longan fruit flesh. Experiment on processing seeds as a substitute of instant coffee.

(5) *Vegetables*: Improvement of canning techniques of bamboo shoots. cxperiment on canning Mushrooms. Experiment on canning gingers. Experiment on the Dehydration of sweet potato. Experiment on the dehydration of Cabbage, Carrot, Radish, Green Peas and soybean sprouts. Experiment on the variation of vitamin A content of dehydrated sweet potato during the storage period. Experiment on the improvement of processing techniques of Chinese confectionaries.

IV. Plant Pathology

A. Rice Diseases

1. *Studies on the Rice Blast Disease*

The outbreak of the rice blast in Taiwan is relative closely to the climatic factors, especially to the temperature. The resistant degree of rice varieties is also an important factor. Generally, the *indica* type of rice varieties are more resistant to the blast disease than those of *japonica* types.

2. *Annual and Local Variation of the Varietal Resistance of Rice to the Blast Disease*

Differences in resistibility of rice varieties to the blast disease was observed in seven experimental localities every year and in different crop seasons. It indicated that the differences in resistibilities among varieties were very low in different regions while the resistibilities of varieties to disease were stable in different seasons. However, in order to obtain basic information for the resistant breeding, physiologic reaction of rice plants as well as physiologic specialization of the fungus must be taken into consideration.

3. *The Effect of Cultural Filtrate of Pyricularia Oryzae and Colletotricum Corchorum to the Disease Control*

The cultural filtrate of *P. oryzae* was used for rice seed treatment. High inhibition of seedling infection by the blast cultural filtrate was not distinguishable.

4. *The Relation of Seedling Reaction and the Leaf Blast of Field Stage*

Inoculations were made both in the seedling stage and field stage. The disease resistibilities increased with growth of rice plants. To select the resistant varieties in the seedling stage is, therefore, of necessity for saving labor, land and time.

5. *The Effect of Fertilization and Chemicals on the Outbreak of Rice Blast*

Proper application of N. P. K. fertilizers is effective in suppressing the outbreak of rice blast in the seedling stage. N-fertilizer is proved to be the most effective to induce the rice blast disease.

6. *Studies on the Physiological Specialization of P. Oryzae*

Cultures of *P. oryzae* were isolated from diseased specimens of various rice varieties collected from several regions of this island. All isolates were subjected to single spore isolation and maintained both on agar slants and in a small test tube which was sealed with vacuum pump.

The cultural characteristics of the blast fungus were studied under different nutritions, different pH values, different temperatures and through successive single spore isolations. To determine the pathogenicity of isolates of *P. oryzae*, rice seedling of 16 differential varieties were inoculated by spraying with spore suspension in green house.

7. *Nutrition of the Rice Blast Fungus, Pyricularia Oryzae Cav.*

The effect of carbohydrates, nitrogen sources and vitamins on the growth of *P. oryzae* were studied. No clear correlation was observed between pathogenicity and nutritional requirement of the fungus.

8. *Rice Seed Disinfection for Disease Control*

To avoid the seed born disease, e. g., rice blast, "Bakanae" disease etc., organic mercury compds have been widely applied for seed disinfection in this island since 1951. Nearly 93 percent of seeds were subjected to the treatment in 1960.

9. Chemical Control of the Rice Blast

Organic mercury compds and nonorganic mercury compds were the most effective chemicals for the control of the rice blast. Demonstrative experiments made around this island proved that the losses from the disease decreased 13 percent by using these fungicides.

10. Chemical Control of the Seath Blight

Organic arsine compds were more effective than other fungicides tested. According to the experiments made in various districts in Taiwan in 1960, the losses from the disease were decreased 9 percent after the application of these compounds.

11. Relation of Fertilization and Rice Varieties to an Outbreak of the Sclerotial Diseases

The disease increased under the condition of excessive application of N-fertilizer. The rice plants were the most susceptible to the disease from 30 to 40 days after transplanting. About 2000 sclerotia formed in each culm. Therefore, in order to decrease the disease outbreak, it is important to avoid culms left in the field after harvest.

12. Studies on the Bacterial Leaf Blight

Bacterial leaf blight is caused by *Xanthomonas oryzae* (U. & I.) Dowson. The disease often occurred during the late stage of rice plant and was more serious in the second crop than in the first one. Generally, the *japonica* type rice varieties were more resistant than the *indicas*.

The physiological characteristics of the causal organism are as follows:

The optimum temperature ranged from 26° C to 30° C, no liquefaction to gelatin, hydrogen sulfide produced on lead acetate medium, indole produced on tryptophane medium, no hydrolysis to starch, produced acid but no gas from the fermentation of glucose, lactose and sucrose.

B. Sweet Potato Diseases

1. Comparison of the Disease Resistance among the Sweet Potato Varieties

Tainang No. 3, Tainang No. 20, Iran and other 6 varieties were comparatively resistant to bud atrophy than the other 32 varieties examined. Tainang No. 3, Keelung and other 8 varieties of the 36 varieties examined were resistant to Black rot.

2. Research on Internal Cork of Sweet Potato

The internal cork tubers of sweet potato were collected from Ma-tao, in 1956. It was reported to be a virus disease.

3. Survey on the Sweet Potato Diseases

Ten kinds of diseases, e.g., Bud atrophy leaf spot, soft rot, southern blight, charcoal rot, black rot etc., were observed in the survey made in Taipei, Tainan and Chiayi areas.

4. Control on Bud Atrophy of Sweet Potato

Application of K-fertilizer is the most economic and simple method for the control of sweet potato bud atrophy.

5. Research on the Storage Diseases of Sweet Potato

To avoid wounding the tubers in the harvest might lessen the storage diseases. One layer of rice straw to five layers of sweet potato was proved to be a good method in storage, it might reserve 25 percent of loss.

C. Fiber Crop Diseases

1. Studies on the Control of Cotton Diseases

(1) *Cotton Seed Treatment for Controlling Seedling Blight and Damping-off*

Several chemicals such as granosan, granosan M, orthocide 75 W. P., uspulum, fernasan 75W, aresan, demosan 65W, granosan L, and tillex have been employed in cotton seed treatment experiments for controlling seedling blight and damping-off since 1958. However, following results were concluded from our experiments.

(a) Regarding the percentage of germination, seeds treated with each of the above chemicals give higher percentage than check by 4 to 9%.

(b) Coating cotton seeds with demosan 65 W has been proved to be the best chemical for controlling damping-off. The cotton seed can be mixed with demosan 65W at the rate of 125:1 (by weight) in 320 c. c. of water.

(2) *Laboratory Test for Controlling Diplodia Boll Rot*

Diplodia boll rot (*Diplodia gossypina*) is a serious disease in the late-growing period. According to the laboratory test, organic compound (i.e. granosan, fuminon, agrosan G) is more effective than copper compound in retarding the germination of spores.

(3) *Studies on the Control of Cotton Disease in Combination with Insect Pests*

The occurrence of several cotton diseases, according to our investigation, is closely related to insect injuries. Hence the application of fungicide in combination with insecticide will be effective in controlling Diplodia boll rot, anthracnose, and angular leaf spot. However, PM 0.1% mixed with 4-4 Bordeaux mixture is found to be effective in reducing the occurrence of diseases and consequently get the high yield.

2. Studies on Diseases of Main Long Fiber Crops and Their Control

(1) *Studies on the Control of Nematode Root-knot*

(a) Method for Determining Field Population of Root-knot Nematode

Some experiments on determining nomatode population in the soil with indicator plant were carried out in 1957. Indicator plants such as tomato and cowpea were interplanted with sweet potato or peanut in the field where kena or jute was scheduled to be cultivated next March or April. Cowpea or tomato seeds were sown among plants of sweet potato or peanut at 30 to 45 days (tomato) or 45 to 60 days (cowpea). Those indicator plants were dug up and their roots were examined for counting nematode root-knot in order to judgef the degree of infection and decide the possibility of kenaf or jute cultivation.

(b) Chemical Control of Root-knot Nematode

The controlling methods of root-knot nematode have widely been sought in

recent ten years. For example, "Irrigation experiment" was carried out in 1955, in which jute were planted 1 or 2 months after fields had been irrigated for 3 months. According to our investigation, it was found that there were non-significant difference between treatments and check. Although irrigation experiment failed to control the disease, surprisingly enough, we succeeded from field practice by continuous inundation for at least 1 month. The experiments on the application of nematicides for controlling root-knot nematode have been done since 1954. The nematicides such as D-D, EDB, Aldrex-2, aldrin, PCNB, nemagon, vapan, fumazon 70E, Dowfume w-85, telone, viddin D etc. may effectively control the disease, but its economical value should be considered before extension.

(2) *Studies on Damping-off Disease of Fiber Crops*

Damping-off disease, caused by *Thanatephorus cucumeris* (Frank) Donk (= *Rhizoctonia solani* Kühn) , is the most serious soil-borne disease of various fiber crops in the seedling stage. Biological studies on this disease have been done extensively since 1933. For the effective control of this disease by means of chemicals, PCNB is proved to be the only practically effective one.

(3) *Kenaf Diseases*

Anthracnose, damping-off, Phyllosticta leaf spot, stem rot and grey mold are the most important diseases of kenaf only next to nematode root-knot. Granosan, captan, and Bordeaux mixture have been used for controlling these diseases. Among them, captan is proved to be better than granosan, and Bordeaux mixture is the least effective one.

(4) *Jute Diseases*

Jute diseases and their control have been studied since 1956. For the control of stem rot, no effective remedy has been found. Much attentions have been paid to the study of jute anthracnose, especially with regard to the physiological characteristics of the causal organism, *Colletotrichum corchorum*.

(5) *Sisal Diseases*

Sisal anthracnose has been studied since 1960. The results show that the disease is physiological rather than mycological in etiology. *Colletotrichum agaves* Cav. and *Botryodiplodia* sp. are the fungi known as the etiological causes. There are also various physiological diseases known as sun scar, yellow spot and unknown wilt.

The sisal anthracnose occurs on those leaves that are injured mechanically or by sun burn. The provalent period of the disease is from May to September in Taiwan.

Harvesting time is also related to the degree of disease damage. According to the severity of the affected plant, March is considered to be the best time for harvesting and June is the next. The worst time for cutting sisal leaves is around September. Harvesting before May may escape the prevalent period of the disease.

D. Oil Crop Diseases

1. The Effect of Seed Treatment to the Control of Southern Blight of Peanut

Several fungicides were employed in seed treatment for peanut southern blight control. Spergon was the most effective one among the fungicides tested, and has been widely used in Taiwan.

2. Chemical Control on Soybean Rust

Among the fungicides tested, Dithane Z-78 and Dithane M-22 gave the best effect on the rust disease control. A total of five applications at one week's interval are currently recommended for soybean rust control.

3. Studies on the Physiological Race of Soybean Rust Fungus

Seven races of *Phakopsora pachyrhizi Syd.* have been characterized from 18 isolates of the rust fungus, on the basis of their pathogenic reaction to the 8 soybean differential varieties.

The leguminous plants other than soybean varieties were also susceptible to races of *Phakopsora pachyrhizi*. The seven races characterized by the soybean differentials could be further differentiated into 6 pathogenic groups on the 8 leguminous plants. Race 3 and Race 4 showed the same pathogenic reaction on the differential host species.

4. Chemical Control of Purple Stain and Soybean Rust

Dithane M-22 was used to control the two kinds of diseases at the same time. Spraying 3-4 times Dithane M-22 at the rate of 1 : 300 in every 10 days gave good control.

5. Bacterial Blight of Soybean Disease

Bacterial blight caused by *Pseudomonas glycinea coerper* has become conspicuous and epidemic in recent years. This disease generally occurs during humid and cool season and is very destructive to the leaves of the soybean plant.

The characters of the pathogen are as follows: Gram-negative; single flagella; green fluorescent pigment produced in culture; gelatin not lignefied; yellow color produced in juice; nitrate produced from nitrates, starch not hydrolyzed; hydrogen sulfide produced; Acid but no gas is formed in maltose and fructose.

E. Citrus Diseases

1. Survey on the Black Spot Disease of Citrus

The disease investigation made in four citrus growing areas indicated that Valencia was the most susceptible to the disease with the infection percent of 42.7-54.58. Ponkan, Tankan came next in order of the infection percent of 35.68-39.95 and 28.80-39.92 respectively.

2. Studies on Citrus Black Spot

The presence of mature perithecia of *Guignardia citricarpa* was observed on old dead leaves of different citrus varieties in various localities of the island. The results of field experiments including staggered spray of Difolatan W-80 and bagging fruits for various intervals after flowering reveal the fact that infection occurs as early as the petal falls. However, mass infection occurs in the early June and last for two months. The results of spore trap confirmed the results of staggered spray and bagging trials.

3. Chemical Control of Citrus Scab

Six fungicides were used to evaluate their effectiveness on the inhibition of sporulation of causal organism in laboratory and on disease control in orchards. Difolatan gave the best results both in laboratory tests and orchard experiments.

Difolatan W-80 at the rate of 12.5g/10l or Delan at 25g/10l applied at times of new flushes, petal falling. Three weeks after second application is being recommended for citrus scab control.

4. Chemical Control of Citrus Greasy Spot

Dethane Z-78, Dithane M-45, Delan, Difolatan and Phaltan each at rates of 25g/10l and 12.5g/10l were used to elucidate their effects on the disease control. All fungicides except Difolatan at 12.5g/10l were significantly effective in suppressing the occurrence of greasy spot disease.

5. Time and Duration of Citrus Leaf Infection by Greasy Spot Fungus

The results of field experiments with two sets of staggered spray of Dithane Z-78 revealed the fact that leaf infection occurred during the months of April and May at Hsin-chu area in 1966.

6. Nematological Studies

Studies on the nematode disease of the citrus have been successfully carried out for nine years. Results indicated the *Tylenchulus semipenetrans* and the *Pratylenchus sp.* would be the most serious pathogens for the citrus. The control experiment is being conducted.

7. Method of Pineapple Mealybug-wilt Control is Being Carried on in Demonstration and Extension

Wilt is the most serious disease of pineapples in Taiwan. It is induced by pineapple mealybugs (*Dysmicoccus brevipes* Ckll.), a common pest of pineapples. Control experiments, prevention measures, and observation on the life cycle of pineapple mealybugs have been taken for years. The present method of control is carried out from these experiments: pineapple seedlings are dipped in Folidol solution (1-3,000) or Malathion solution (1-1,000) for 2 minutes before planting. Then it is followed by pouring Folidol solution (1-3,000) on the central part of the pineapples, 100cc. per plant, for 3-4 times with 3 month intervals. Aldrin (0.2%) may be used to control ants. This Procedure has been proved to be very successful, and adopted for extension by the Government since 1954. The linear increasement of pineapple cultivation in South Taiwan is directly due to the success of mealybug wilt control.

F. Vegetable Diseases

1. Maintenance of Virus X Free Potatoes

Efforts have been made to eliminate PVX from potato plants in order to obtain PVX free tubers by using serological methods for the purpose of propagating healthy tuber. Through four times of field inspection and two times of tuber indexing in green house, PVX was eliminated completely from potatoes successively subjected to inspection.

2. Seed Treatment for Control of Southern Blight of Kidney Bean

Among the ten fungicides tested for their effectiveness in protecting kidney bean seedlings against southern blight fungus invasion, semesan at the rate of 0.3% gave the best result.

3. Seed Dipping for Control of Cabbage Black Rot

Of three fungicides tested, Mercuric chloride and Granosan were found to be satisfactory for control of the black rot disease of cabbage. Application of Granosan at the concentration of 0.1% for 20 minutes or mercuric chloride at 0.1% for 10 minutes are currently recommended for control of the disease by seed-dipping.

4. Survey on the Asparagus Diseases

The disease survey made in the nine asparagus growing areas revealed that *Cercospora* blight caused by *Cercospora asparagi* was the most destructive disease in seedling stage, and stem blight caused by *Phoma asparagi* was the most serious disease in field stage. These diseases were noticed to cause considerable damages to asparagus plants frequently, thus lowering both the quantity and quality of the asparagus seedling and production.

5. Pathogenicity of the Causal Fungus of Asparagus Stem Blight

Wound and woundless inoculation were made with pycnidiospore suspension by spraying on stems of asparagus plants growing in pots. The results revealed that the infection of the causal fungus took place on both wounded and unwounded plants. However, the infection of the causal fungus takes place more easily on wounded tissue than unwounded one.

6. Fungicidal Screen Tests for Control of Asparagus Stem Blight

Toxic effect of fungicides on pycnidiospore germination and mycelial treatment were made in laboratory. Among the 8 fungicides tested, Suzu tablet, Dithane M-22, Dithane stainless, Arasan had the good results in inhibition of pycnidiospore germination, and Suzu tablet gave the best results in mycelial treatment. Suzu tablet at the concentration of 250 ppm. can kill the mycelium after 10 minute treatment.

G. Medical Herb Crops Diseases

1. Survey on the Mint Diseases

Field investigations made in Yunlin and Chiai areas revealed that leaf spot, rust and powdery mildew were the three important diseases of mint occurred in Taiwan.

2. Chemical Control of Mint Powdery Mildew

Six fungicides, namely Dithane Z-78, Dithane M-22, Dithane S-31, Suzu tablet, KB-90 and Ruston were tested for their effectiveness in controlling mint powdery mildew. Dithane M-22 at the concentration of 1:200 gave the best control of the disease.

3. Chemical Control of Mint Rust

Six fungicides, namely Dithane Z-78, Dithane M-22, Dithane S-31, Suzu tablet, KB-90 and Ruston were compared for the control of mint rust. Dithane M-22 at the rate of 1:200 was the most effective in controlling the disease. However, for the practical control of mint rust, two applications of Maneb started on 62 days after planting is being recommended.

H. Studies on the Mushroom

1. Varietal Selections of Mushroom

This experiment started in 1960 and has been carried on since. During the last few years, 8 selected strains, namely 54-2, 54-3, 54-7, 55-10, 55-11, 55-12 and 55-13 were used for the commercial purpose. A further experiment with 9 strains as 54-2, 54-3, 54-4, 54-7, 55-9, 55-10, 55-11, 55-12 and 55-13 was carried in 1968. The yield productions were tested all over the 7 representative localities in the northern, central and southern parts of Taiwan. The results of the experiment show fhat the average yield of different strains is 22.35g/ping and the highest yield is 36.36g/ping. There is no significant difference between the yields among the strains. According to the average yield obtained, it is known strains 55-10 and 55-3 are more productive for the northern part, 54-7 and 55-10 are the best for the central part, and 54-2, 54-3 and 55-10 are diserable for the southern part.

2. Comparison of the Vitality of Mushroom Multiplied by Spores and Tissues

Growth of fungus mycelium was more vigorous when it was obtained from spore germination than that from mushroom tissues. However, there was no difference between the yield productions of mushroom fruiting bodies in both cases.

3. Study on the Methods of Preserving Desirable Mushroom Varieties

Basidiospores of mushroom collected in a small test tube were sealed in an ampoule under a pressure of 3 mm-Hg. The spores retained viability after 4 years' storage (1964-1968) when the ampoules were kept at-20°, -4°, 0°, 5° and 25°C under natural conditions, only it took 10 days to germinate; more than 5 days was needed as compared with the fresh spores germination. No decrease in mushroom yield was observed when they were used as inoculum.

4. Mushroom Disease

(1) *Mushroom Disease Survey in Taiwan*

There are 33 kinds of mushroom disease which have been identified in the samples supplied by growers in Taiwan, particularly during the period of mushroom raising. Among these pathogens, 16 genus are imperfect Fungi; 9 genus Ascomycetes; 3 genus Phycomycetes and the others are the Basidiomycetes. Besides, there is one type of nematode and several types of malformed mushroom caused by physiological disease.

(2) *Studies on the Truffle Disease of Cultivated Mushroom*

A physiological investigation was made on the comparison of cultivated mushroom with truffle disease causal organism. The temperature, water, pH and the utilization of nitrogen were studied in order to find an effective method for the controlling of the disease. The results are as follow:

(a) According to the mushroom disease survey in 1968, it is found there are a few diseases occurred this year. Fusarium, which hadn't mentioned before, is more serious than the others.

(b) Sterilized mushroom houses and the tested composts result in a good production.

(c) The amount of chloropicrin on the compost fumigation relates to the temperature involved. Generally speaking, the amount decrease during high temperature and vice versa.

(d) Strain 54-7 highly resists trichoderma.

(e) 30g of fine tobacco residue per 100g of dry compost can prevent the growth of truffle mycelium.

(3) *Chemical Control on Mushroom Disease*

Vapam, Grand, Basamid and chloropicrin effectively inhibit six kinds of pathogens including truffle fungus. The casing soil and the compost treated with these chemicals should be applied only after treatment of 3-5 and 7-15 days respectively. Copper sulfate at 0.1% concentration does not show any effect on truffle disease in subtropical area.

I. Miscellaneous Studies on Diseases of Vegetable and Fruit

The following accounts of diseases are the accomplishment of Fengshan Tropical Horticultural Experiment Station:

Name of Diseases	Hosts	Fungicides & Concentration	Time of Application
Downy mildew (*Pseudoperonospora cubensis*)	Cucumber	Daconil, Vegeta, Delan k (1:500) or Dithane M-22 (1:400)	7 days intervals
Powdery mildew (*Sphaerotheca fuliginea*)	Cucumber, watermelon, melon.	Karathane or Morestan (1:1,000)	
Fusarium wilt (*Fusarium oxysporum f. niveum*)	Watermelon	Similton, Soilcin (1:1, 000) or Grand (1:650), 1-2 l. per plant	1. Seeds disinfection 2. Before planting, flowering, fruiting by pouring the solution to each plant.
Anthracnose (*Colletotrichum lagenarium*)	Watermelon	Mon or Neo Asozin (1:1,000)	7 days intervals
Late blight (*Phytophthora infestans*)	Tomato	Dithane M-22 (1:400), Dithane M-45, ,Dithane Stainless, Antracol, Polyram Combi (1:500), or Daconil (1:600)	5—7 days intervals
Heart rot (*Phytophthora parasitica, p. cinnamomi*)	Pineapple	Difolatan (1:200)	Seedlings dipping
Anthracnose (*Colletotrichum gloeosporioides*)	Mango	Difolatan (1:400)	1. From flowering to fruiting, weekly 2. Fruit development, monthly
Leaf spot (*Cercospora musae*)	Banana	Dithane M-45, Antracol or Topsin 2.8kg+Mineral oil 6 l.+Triton×-114 80c.c.+Water 24 l. per hec.	Twice a month

V. Applied Zoology

A. Insect Collection

The insect collection of the Institute was established in 1907. It has grown up to over 500,000 insect specimens, in which approximately 4,000 type specimens are included. The major groups of insect specimens in the collection are ODONATA (dragonflies & demselflies), HOMOPTERA (aphids & scale insects), COLEOPTERA (beetles & weevils), LEPIDOPTERA (butterflies & moths) and HYMENOPTERA (bees & wasps, etc.). Majority of the specimens are collected on this island and a number of them are from exotic expeditions (i.e. China mainland, Korea, Japan, the Philippines, Viet-nam, Thailand, Micronesia and New Guinea) or through international exchange. Since the whole collection was beyond attention during the World War II so that great efforts have been made by the Institute to rehabilitate the insect collection. With the financial assistance of the Joint Commission on Rural Reconstruction from 1954 to 1968, we were able to make a good progress in the collecting, mounting and managing of insect specimens. In addition, the JCRR assistance also made it possible for us to rearrange the whole insect collection according to the systematic orders; to prepare a series of catalogue cards for all identified specimens. All unidentified specimens are also available to taxonomic studies. Some groups of specimens are ready for loan or exchange which will enable the researchers to identify the insect specimens more accurate and lead us to have better knowledge on the insects of Taiwan.

A Bibliography of Entomology in Taiwan (1684-1957) was published in 1958 with the financial assistance of the JCRR. The first supplement of the bibliography from 1957 to 1966 was also published in 1967. It is believed that the comprehensive bibliographies are the most useful tools for entomologists to study the insects of Taiwan and its adjacent areas.

B. Insect Taxonomy

Since the returning of Taiwan to China, our Government has paid much attention to the reconstruction and development of Taiwan economy so that the work in our department was concentrated on the study of economic entomology. However, the taxonomists in the Institute could also make some extensive studies on several groups of insects from Taiwan and other parts of the world. Contributions were made to some revisional studies and the descriptions of new genera and new species.

1. Genera of Odonata: *Orolestes*, *Psolodesmus* and *Chlorogomphus*.
2. Families of Hemiptera: Phymatidae and Urostylidae.
3. Families of Homoptera: Machaerotidae, Aphidae.
4. Genera of Mecoptera: *Panorpa*, *Neopanorpa* and *Bittacus*.
5. Superfamilies and families of Hymenoptera: Megalodontoidea, Siricoidea, Cephoidea, Ichneumonidae, Aphidiidae, Pteromalidae, Eulophidae, Loboscelidiidae, Eucoilinae, Methochidae and Cleptidae.

C. Useful Insects and Snails

1. Beneficial Snails

The Giant African snail, *Achatina fulica* Bowd.(Achatinidae)is a common plant pest which has its origin in Eastern Africa and then spread to the Pacific. In 1934 it was intentionally introduced to Taiwan by the Japanese who erronously believed that the mollusk had both medicinal and food value. However, after only a short period, the snail became an important pest in both agriculture and forestry because of its large size, diversified food habit, high reproductive ability and wide distribution. After the World War II our entomologists tried very hard to control the snail by using of different chemicals but to no avail.

Two carnivorous snails, *Euglandina rosea* Ferru. (Oleaclnidae) and *Gonaxis quadrilateralis* (Preston) (Streptaxidae) from Hawaii were then introduced to Taiwan in 1959 and 1961 respectively for the purpose of controlling the Giant African snail. A bionomic study and mass production of the two predaceous snails have been carried out in our department for years. The results indicated that both of them were good predators of the Giant African snail. *Euglandina* snail showed more active and effective in controlling *Achatina* snail on the large area of southern Taiwan. The *Gonaxis* snail was considered to be more suitable for being released to the small area of the northern part of this island. The two beneficial snails had longer period of activity then the Giant African snail under Taipei outdoor conditions. Their egg stages could extend to 3 or 4 months if the environmental conditions were unsuitable for its development.

2. Natural Enemies of the Phytophagous Mites

Two groups of predators preying on the phytophagous mites were collected in the last two years. They belong to Insecta and Arachnida as follows:

Insecta including 4 orders and 9 species: Coccinellidae (3 species), Staphylinidae (1 species), Thysanoptera (2 species), Diptera (2 species), Chrysopidae (1 species).

Arachnida including 5 genera and 8 species of Phytoseiidae: *Ambylseius*(3 species), *Amblydromellus* (1 species), *Cydnodromus* (1 species), *Phytoseius* (1 species) and *Garmania* (2 species).

3. Lac Insect

The bionomics and refining studies of lac insect were published in 1948. It reported that the Lac Insect, *Laccifer lacca* Kerr in Taiwan had two generations a year. First generation required 110 days from first of April to the end of July. Second generation required 225 days from first of August to the end of coming March.

In 1947, the yield of Lac of the Ist generation was about 38.8 times more than that of 1941. The yield of 2nd generation was about the same as that in 1941. Ist generation bred on *Cajanus cajan* Mill had 299.63 grams per tree. A noctuid, *Amabilis roseonirea* Walker was found to feed on the stick lac. It should be controlled early while the moth was found on the local lac insect *Laccifer greeni* Chamb.

The percentage of refinement from stick lac to shellac was 54-91%. During refining, the crushed stick lac had to be washed many times and soaked in 2% normal saline over 24 hours before the qualified shellac was obtained. Though, alcoholic refining method was much better than the heating refining method, the former method

was too expensive for mass production. Temperature of the heating refining method must be kept under 100°C. The quality of refined shellac from not overwintered stage always showed much better than that from the overwintered stage but the yield was lower.

4. Natural Enemies of Citrus Insects

The information obtained from a survey on the natural enemies of the following citrus insects were very useful for the integrated control of citrus insects in Taiwan.

(1) Citrus dogs including *Princepts demoleus libanius* Fruhstorifer and *Papilio xuthus hoxinga* Fruhstorifer, etc: Egg parasites: *Trichogramma australican* Girault (Trichogrammatidae) and *Telenomus* sp. (Scelionidae). Larval parasites: *Melalophacharops papilionis* Ashmead (Ichneumonidae) and *Exorista sorbillans* Wied (Tachnidae). Pupal parasite: *Pteromalus puparum* Linne (Pteromalidae).

(2) Citrus leaf miner, *Phyllocnistis citrella Stainton*: Larval parasites: *Cirrospilus ingennus* Gahan (Eulophidae), *Tetrastichus* sp. (Eulophidae) and *Ageniaspis* sp. (Encyrtidae).

(3) Citrus sting bug, *Rhynchocoris humeralis* Thunberg: Egg parasites: *Anastatus formosanus* Crawford (Euphelinidae) and *Telenomus latisulcus* Crawford (Scelionidae).

(4) Citrus spiny white fly, *Aleurocanthus spiniferus* Quaintance: Pupal parasite: *Amites hesperidum* Silvestri (Platyasteridae). Predators: *Acletoxenus* sp. (Drosophidae) and *Serangium* sp. (Coccinellidae).

(5) Citrus psylla, *Diaphorina citri* Kuwayama: Nymphal parasite: *Psyllaephagus* sp. (Encyrtidae).

(6) Aphids including *Toxoptera citricida* (Kirkaldy), *T. aurantii* (Boyer). *Aphis spiraecola* Patch and *A. gossypii* Glover etc.: Predators:*Coccinella repanda* Thunberg, *C. octopunctata* Fabricius, *C. septempunctata brucki* Mulsant, *Coelophora chinensis* Weise, *Leis dimidiata* Fabricius, *Lemnia swinhoei* Crotch, *L. biplagiata* Swartz *Menochilus sexmaculatus*(Weise),*Platynaspidis maculasus* Weise, *Propylaea japonica* Thunberg, *Pseudaspidimerus japonensis* Nakane et Araki, *Scymnus (Pullus) hoffmanni* Weise, *S. frontalis quadripustulatus* Herbst, *S.* sp. and *Synonycha grandis* Thunberg of Coccinellidae; *Ischiodon scutellarius* Fabricius, *Melanostoma orientale* Wiedmann, *M. univittatum* Wiedmann, *Paragus serratus* Fabricius, *P. tibialis* Fallen, *Sphaerophornia cylindrica* Say, *S. javana* Wiedmann *Epistrophe balteatus* Fabricius, *Metasyrphus corollae* Fabricius, *Syrphus aegrotus* Fabricius, *S. confrator* Wiedmann, *S. horishanus* Matsumura, *S. serarius* Wiedmann and *Xanthogramma citrifasciatum* de Geer of Syrphidae; *Leucopis puncticornis* Meigen of Ochithiphilidae; *Ankylopteryx octopunctata* Fabricius, *Chrysopa boninensis* Okamoto, *Ch. septempunctata* Wesmael and *Ch.* sp. a of Chrysopidae; *Eumicromus sauteri* Esben-Petersen of Hemerobiidae and *Orius* sp. of Anthocoridae.

(7) Cotton cushion scale, *Icerya purchasi* Maskell: Predators: *Rodolia cardinalis* (Mulsant) and *R pumila* Weise of Coccinellidae.

(8) Mealy bug, *Nipaecoccus filamentosus* (Cockerell): Predators: *Cryptolaemus montrouzieri* (Mulsant), *Scymnus (Nephus) ryuguns* Kamiya of Coccinellidae. Parasite: *Anagyrus sawadai* Ishii of Encyrtidae.

(9) Florida red scale, *Chrysomphalus ficus* Ashmead: Predators: *Pharoscymnus taoi* Sasaji and *Telsimia nitida* Chapin of Coccinellidae, *Cybocephalus* sp. of Nitidulidae. Parasites: *Aphytis chrysomphali* (Mercet) of Aphelinidae.

(10) Citrus red mite, *Panonychus citri* Mcgregor: Predators: *Stethorus japonensis* Kamiya of Coccinellidae, *Oligota* sp. of Staphylinidae, *Scolothrips sexmaculatus* Pergande of Thripidae and *Leptothrips* sp. of Thysanoptera.

(11) Green scale, *Coccus viridis* Creen: Parasites: *Coccophagus lycimnia* Walker, *Aneristus ceroplastae* Howard of Aphelinidae and *Microterys speciosus* Ishii of Encyrtidae.

(12) Aphid parasites: A biological control of the citrus, tobacco and vegetable aphids was conducted in 1965. Twelve species in seven genera of hymenopterous parasites on the six aphids *Acyrthosiphon pisum* (Harris), *Aphis gossypii* Glover, *Aphis spiraecola* Patch, *Brevicoryne brassicae* L., *Myzus persicae* Sulzer, *Toxoptera aurantii* (Boyer de F.) *Toxoptera citricida* (Kirk.) were reported as *Aphidius gifuensis* Ashmead, *Binodoxys communis* (Gahan) *Binodoxys indicus* Subba Rao and Sharma, *Binodoxys struma* (Gahan) *Diaeretiella rapae* MacIntosh, *Ephedrus persicae* Froggatt, *Ephedrus plagiator* (Nees) *Ephedrus robustus* Liu, *Lipolexis gracilis* Förster, *Lipolexis scutellaris* Mackauer, *Lysiphlebia japonica* Ashmead of Aphidiidae and *Aphelinus mali* Hald. of Aphelinidae.

D. Insect Pests and Their Control

1. Paddy Borer, Tryporyza Incertulas Walker and Brown Plant Hopper, Nilaparvata Lugens Stal

The 14 kinds of organophosphates tested and arranged in relative toxicity were ethyl parathion ((118.3)>folidol (100)>alkron (96.9)>pax (94.3)>PM (90.1)>diazinon (90.0)>gusathion (85.6)>EPN (83.6)>trithion (80.8)>chlorthion (79.5)>methyl parathion (76.5)>dipterex (58.9)>diethio systox (40.6)>metasystox (22.1).

The killed larvae were believed to be due to penetration of the chemicals rather than the systemic or fumigating effect. The chemicals would go into the leaf sheaths through the punctures previously made by the larvae which would thus be killed. The larvae in the upper part of the plants were not liable to be killed. Residual toxicity was only within 4 days but entirely in effective 8 days after application. Ist to 3rd instar larvae were killed within 1-3 days. At 20-60 days old plant 4-9 cc. of diluted concentration per hill was enough to kill them.

The chemicals stocked longer were lower their toxicity. Shower happened 30 minutes after spraying. The speed of shower was 5-7mm. per minute for an hour did not reduce its toxicity.

Chlorinated hydrocarbon as endrin, aldrin and DDT were also tested. It showed that their residual function was endrin 16, dieldrin 8, aldrin and DDT 4 days respectively.

In the results of field trials that 19.5% endrin ec diluted 800 times (about 1 pound in 100 imperial gallons of water), 3 applications would provide excellent control, while folidol, gusathion, PM and diazinon were the same results. Folidol plus endrin were not increasing its effects.

Field trials of calcium cyanamide when applied the rice stubbles while they remained fresh on properly moistened doil, was effective against the rice borer larvae overwintering in the subterranean part of the culms.

With several exceptions, the kill by calcium cyanamide took place within 2 days after the application, during which the mortality varied from 11 to 13%. It increased gradually and usually ceased after 8 days; during this period the mortality varied from 50 to 73%. The insect seems to be killed not only through decay of the stubble caused by calcium cyanamide, but also properly acts as a fumigants.

A dosage of 0.5 gram was as effective on stubble cut at the surface of the soil as 1 or 2 grams applied to normal stubble, 6 to 8 cm high.

Due to the mortality was not constantly high enough by using calcium cyanamide so it did not recommend for control paddy borer.

In recent years, the brown plant hopper *Nilaparvata lugens* Stal., has increased in numbers and is now considered to be the most serious rice pest in the warmer central and southern regions of Taiwan. The chemical control result from tests carried out by Chiayi Station between 1962 and 1966. Of the insecticides tested, endrin, dipterex, sevin and bidrin gave the best results.

It can be seen that over the years, *Nilaparvata* control increased yield on average 76.6%.

2. *Soybean Insects*

Soybean is a new protein and oil crop in Taiwan. The most important pests of the crop are root miner *Melanagromyza* sp. and stem miner *Melanagromyza* (*Agromyza*) *phoseoli* Coq. (Agromyzidae, Diptera). These two miners may be new to Taiwan. They attacked the seedling of soybean and then destroy the crop entirely. The insecticidal treatment suggested for use in the control of these miners was one and four weeks after the summer soybean sowing, spraying with 19.5% endrin ec 500–1,000 times concentration. That treatment was also effective in controlling leaf miner, *Melanagromyza* (*Agromyza*) *sajai* Zehn of soybean. Recently, applying 5% PSP 204 or 5% Disyston granule 20 kg/ha as row treatment during sowing was more economic than spray.

3. *Sweet Potato Insects*

The sweet potato weevil, *Cylas formicarius* Fabricius had 8 generations a year. One generation usually took 22–86 days. The infestation of the spring crop was heavier than the autumn crop. However, to grow early varieties and to harvest earlier as well as crop rotation were the best control method for the insect.

The good control could be obtained by dipping cuts in 0.25% DDT ec for 2 minutes then took off and planted when it was dried. Adding 2 applications of the same chemical and same concentration at 7–9 and 14–16 weeks after setting of early varieties and 9–11 and 19–21 weeks of late varieties respectively. Apparently, the first application was very easy because the vines of plant were not heavy. So, during the second application, vines had to be turned all over for spraying thoroughly. This treatment may increase about 80% the yield of vines, and 20–30% the yield of tubers respectively.

Soil treatment with 1 ppm of aldrin, heptachlor or dieldrin before planting was not so good to reduce sweet potato weevil infestation but it was quite effective against the sweet potato leaf beetle, *Corasposoma oberthuri* Jacoby and other subterranean insects such as giant cricket *Brachytrupes portentosis* Lichtenstein, cricket *Gryllus mitratus* Burmeister, mole cricket *Gryllotalpa africana* Palisot de Beauvois, white ant *Odontotermes formosanus* Shiraki and green May beetle *Anomala expansa* Bates. Consequently, the above treatments showed very ideal in the field control demonstrations of sweet potato insects. The soil toxicant residue could be detected even after 200 days.

4. *Cotton Insects*

(1) *Studies on General Characteristics of Spiny Bollworm*

It has been found that the adult period is 3 to 9 days, egg period is 3 to 9 days, larva period is 10 to 21 days, and pupa period is 5 to 14 days. Each generation is 21 to 53 days. The insect seriously occurs from September to October every year.

(2) *Ecological Studies on Cotton Bollworm* (*Heliothis zea Boddie*)

The insect occurs 6 generations annually. The duration of one generation varies under different environmental conditions, the shortest takes 21 days at 33±2°C. Each female can lay 1,200 eggs within 11 to 25 days. The egg period is 8 to 18 days at 21.4°C, and 2 to 7 days at 24±1°C. The larva period is 23 to 26 days at 21±4°C, and 17 to 23 days at 23±2°C. The pupa period is 8 to 30 days at 25°C. The adult period is different between male and female, however, the longevity of the female is 22±7 days and the male 11±3 days.

(3) *Experiments on the Control of Cotton Insect Pests*

In order to control the major cotton insects, i.e. *Earias fabia*, *pectinophora gossypiella*, and *Chlorita biguttula*, endrin, BHC, DDT, dieldrin, aldrin and sulphur were tested in 1953. Endrin was considered the most effective insecticide for controlling cotton insect pests until 1961. In the comparative test of 19.5% endrin emulsion (0.04%), 50% sevin W.P. (0.1%) and thimet granules (2 lbs/acre and 4 lbs/acre) in 1961, however, sevin W.P. was found slightly better than endrin emulsion both in yield production and insect occurrence.

5. *Jute Insects*

Leaf hopper, army worm, red mite, jute looper and stem weevil are the most important insect pests on jute. Among them, jute weevil (*Apion corchori* Marshell) is found to be the most destructive one. The insect was first discovered from jute field in Sueishang township of Chiayi county in 1960. Both adults and larvae may cause serious damage to jute plant, particularly the larvae. The adults suck the young stems

and young capsules, and lay eggs loosely beneath the epidermic cells layer of stem or petiole. The longevity of the life cycle varies with the environmental conditions. The longest egg stage has been observed to be 124 days. Under room temperature, the egg stage is 3 to 5 days, larva stage 8 to 18 days and pupa stage 4 to 5 days. The longest life cycle requires 209 days. The generation begins in early July. It reaches the peak of overrun from Augest to October. For chemical control, a proper method is to use 18.5% dieldrin emulsion (HEDD) diluted to 500 times.

6. Kenaf Insects

Corn borer (*Pyrausta nubilalis*). may bettle (*Anomala expansa*), spiny bollworm (*Earias fabia*) and leaf hopper (*Chlorita biguttula*) are four injurious insects on kenaf. Corn borer is the most destructive one among them. The annual occurrence is varied from 10 to 40%. It was suggested in 1957–1958 that trap crop method was the most effective and practical in reducing the occurrence of corn borer on kenaf. Therefore, corn and sorghum may be utilized as trap crops. By sowing corn as a trap around the kenaf field at the same time as kenaf, corn borer would infest heavily on corn from late May to early June but very lightly (below 5%) on kenaf. In early June, corn should be removed from field and burnt to kill the borers. Spray a few rows of kenaf adjacent to the trap crop with endrin, and then cut down the infested plants to prevent the further spreading of the insect. The practice has been found very effective in controlling the European corn borer on kenaf.

7. Flax Insects

28 kinds of noctuid insects have been found on flax field. Among them, 8 are the most destructive. They are *Heliothis zea*, *Prodenia litura*, *Phytometra intermixta*, *Cirphis unipuncta*, *Anomis fimbriago*, *Phytometra ni*, *Laphygma exigua*, and *Agrotis ypsilon*. For controlling these insect pests, 25% DDT emulsion, 75% DDT W.P., 50% sevin W.P. and 19.5% endrin emulsion will be effective.

8. Sisal Insects

Sisal has been considered relatively free from attack by insects. Mealybug is the only injurious insect on sisal leaf. Now the destruction and overruning situation of mealybug are being studied to scatch for effective field control methods.

9. Stored Grain Insects

The life histories of *Sitophilus oryze* Linne and *Rhizopertha dominica* Fabricius were studied in 1958. *Sitophilus oryzae* Linne, *Rhizopertha dominica* Fabricius and *Tribolium ferrugineum* Fabricius were the three main stored grain insects in Taiwan. Pyrenone and Lindane were used for the control studies as follows:

1.28% Pyrenone (pyrethrin 0.08 plus piperonyl butoxide 1.2) 1:500, and 1:700, Lindane 0.2% 1:500 (4 ppm) and 1:800(2.5 ppm) mixed with rice or wheat were stored for 8 months. It showed that the insecticides at various dosages were very effective in controlling the above grain insects but lindane was a little more toxic and much more persistent than pyrenone. After four months of storage, the toxic effect of the grains treated with pyrenone were significantly decreased due to the Taiwan climatic condition. Lindane at 4 ppm as low as 2.5 ppm gave almost complete protection of rice, *kaoliang* and wheat from the storage pests for at least eight months. Spraying the two chemicals on the dried slices of sweet potato had given very poor results.

To use Lindane against stored grain insects was superior than pyrenone, but it might cause some harm to human being and live stocks. So that malathion, alodan and bromodan were also tested recently. The results showed that 4 ppm of malathion had already lost its effectiveness after three months of storage, but its initial effect was very good in killing *Tribolium ferrugineum* Fabricius. Bromodan 1:500 and 100 ppm of alodan were still effective even after three months of storage. They had 89.58%, 85.71%, 56.25% and 67.35% in mortality of *Sitophilus oryzae* and *Rhizopertha dominica* respectively.

The seed gernimation percentage of rice, wheat and soybean was not effected by the application of Lindane and Pyranone even in high concentration up to 40 ppm of Lindane.

Grains treated with phostoxin fumigation was also tested. It showed more effective than applying chemical impregnated dust. Moreover, the chemical impregnated dust like Lindane has already been resisted by granary insects. So, phostoxin fumigation substitute for chemical impregnated dust seemed necessary to be adopted in the future. A detail study on grain treated with phostoxin fumigation under different conditions of storage had been done all over the island.

10. Citrus Insects

In 1950, the department cooperated with the China Petroleum Corporation to refine the white or summer oil. It was used to the control armored and unarmored scale insects in place of resin soda wash being used before. The summer oil could also be mixed with either one of malathion, copper, zineb, sevin for the controlling of other insects. But, Dimethoate ec was found to be the best insecticide for scale insects, red mites, etc.

Since tristeza discovered and spread all over this island. Black aphid, *Toxoptera citricida* (Kirkaldy) had soon become a most important problem to us. The applications of Metasystox (i) 0.025% or ekatin 0.05% could obtained a good control. And it might be able to replace the frequency application of malathion in spring flushing.

By the end of April or early May, a sprayed or brushed of Diedlrin 0.05% on the trunk below the height of knee and downward to the ground was effective in controlling root borer, *Anoplophora maculata* (Thomson) and to prevent the egg laid into the bark. This method can be in stead of weekly hand picking method in summer and autumn. And it was also much easier than to search for the tiny eggs and larvae which were in the trunk.

The effective period of applying Zineb or Maneb at the concentration of 2,000 times to control the rust mite persisted 70 days long (c.f. lime sulfur lasted only 30 days). Zineb or Maneb can be mixed with either one of malathion, summer oil or sevin to control other citrus insects. Zineb always made the fruits more colorful as well as lime sulfur. The cost of Zineb and lime sulfur was about the same. But the former

one could save 1 or 2 applications within a year so its cost was cheaper. Even lime sulfur is a good miticide, it usually induced sun burn when it was applied in host summer.

Methyl eugenol plus toxicant as DDVP or either one of pyrolan, malathion or parathion may attract male oriental fruit fly, *Dacus dorsalis* Hendel. It had been used in the seasonal population survey or as an indicator to evaluate the effectiveness of bait spray against fruit fly. But it was still not used in male annihilation due to the complicated environment in Taiwan. Yeast powder made by the Taiwan Sugar Corporation had been proved as a powerful attractant for bait spray as well as the imported yeast protein.

Since the extensive and frequency application of organophosphorous insecticides i.e. malathion, parathion, gusathion, dimethoate, sayfos, dimecron, ekatin, metasystox (i) to control scales, aphids, psylla, white flies, leaf miner and citrus dogs significantly induced the high population of citrus red mite. These organophosphorous insecticides could not only check those insects but also kill their predators like *Stethorus* and *Oligota* beetles, so the citrus red mite problem become very severe at present. Besides, the acaricides like chlorobenzilate and tedion were also not able to control citrus red mite which had already resisted to these acaricides.

For overcoming the above trouble, the Institute had designed some integrated control of citrus insects so called spot, skip or alternate application of insecticides when the chemical control is necessary. Otherwise, it may be left alone without spray, the population of citrus red mite will naturally go down again below the economic level.

The water soluble systemic insecticide, Azodrin painted on the bark of tree near ground at flushing could obtained a good control of most young foliage insects like *Aphis spiraecola* Patch, *Toxoptera citricida* (Kirkaldy), *Phyllocnistis citrella* Stainton, *Diaphorina citri* Kuwayama, *Chrysomphalus ficus* Ashmead and *Phyllocoptruta oleivora* (Ashmead). Meanwhile, a liberation of *Trichogramma australicum* Girault for the control of citrus dogs in such a chemical painting citrus grooves had also indicated a successful establishment. Therefore, the integrated control of citrus insects was perfectly successful in the demonstration. It could save not only the costs of water, labors and insecticides but also protecting many kinds of the natural enemies of citrus insects. In a word, it will be able to check the above young foliage insects plus *Panonychus citri* McGregor and maintain its population far below the economic level at any time.

11. Banana Insects

Banana mealybug is the most injurious insect pest of banana especially in the southern part of Taiwan. A number of them are always living in flocks by sucking the juice with their tube-like months, on almost all parts of the banana plant. Since the banana fruits are strictly prohibited from exportation at the appearance of mealybug, so the influence in reducing the income of foreign exchange is very serious.

The effective control was cleared from the results of this experiment. Both of

Diazinon e.c. and Sumithion e.c. at 0.05%, gave the excellent mortalities. The treated plot with applying 3 times was as high as 100% effectiveness.

12. Litchi Insect

Erinose mite of litchi, *Eriophyes litchii* Keifer, is one of the most serious pest in centro-southern Taiwan. As an affected leaf sometimes contracting and swelling, many orchardists mistake the erinose for a kind of diseases and name it leaf-dwarf or leaf-hypertrophy of litchi.

In our former works in 1950-1952, the best result of control is given by Lime-sulphur at 0.3-0.5 'Be, but vewing to its phytotoxicity, it is unsatisfactory to apply. From the result of this study, the best control was shown by Chlorobenzilate at 1:1,000. Sulton (wettable sulphur) at 1:300 and Pestan at 1:1000 were also very excellent.

13. Mango Insect

The larvae of mango twig borer (*Chlumetia transversa* Walker) bore into the twigs both of young shoots and inflorescences of mango trees and cause them wilting or unfruitfulness.

According to an observation of seasonal occurrance, there are two outbreaks of this insect pest in a year round. One is in March when the mango tree shoots its inflorescences, and the other is in November when the mango tree shoots its new branches. And the damage caused by the pest of first outbreak is more serious than that of the second one.

The control work consisted of spraying at branching period and blooming period. From the result, we cleared that treatment at blooming period was more efficient than that of the same at branching period. The better three among the chemicals were Sumithion e.c. 0.05%, Lebaycid e.c. 0.05% and Sevin w.p. 0.1%. It is suggested that a better time for control should begin in early January for the first outbreak, and in early October for the second outbreak.

14. Cruciferous Insects

Myzus persicae Sulzer, *Lipaphis erysimi* Kaltenbach, *Prodenia litura* Fabricius, *Phytometra ni* Hubner, *Phalaena (Tinea) xylostella Linnaeus, Oebia (Helluda) undalis* Fabricius etc. usually appeared at the same season in Taiwan. Rotenone combined with DDT, or malathion only, was found to be the adequate control measures.

To use high toxic insecticides on the edible part of vegetables near harvest,it induced the residue. Therefore, the department had tried on some insecticides against these insects. We found phosdrin might be a good substitute for endrin and parathion to avoid the residue problem. Anyhow, the operator still has to pay his attention on applying this chemical.

Dusting 1% r BHC 20kg per hectare when seeds of vegetables were sowed. It was the cheapest and easiest control method against turnip flea beetle, *Phyllotreta vittata* Fabricius in spring and summer season. 2 or 3 applications of 5 to 7 days interval immediately after the buds appeared were also effective. However, Sevin 50% wp 1:500 was found as the most effective method for controlling this beetle recently.

one could save 1 or 2 applications within a year so its cost was cheaper. Even lime sulfur is a good miticide, it usually induced sun burn when it was applied in host summer.

Methyl eugenol plus toxicant as DDVP or either one of pyrolan, malathion or parathion may attract male oriental fruit fly, *Dacus dorsalis* Hendel. It had been used in the seasonal population survey or as an indicator to evaluate the effectiveness of bait spray against fruit fly. But it was still not used in male annihilation due to the complicated environment in Taiwan. Yeast powder made by the Taiwan Sugar Corporation had been proved as a powerful attractant for bait spray as well as the imported yeast protein.

Since the extensive and frequency application of organophosphorous insecticides i.e. malathion, parathion, gusathion, dimethoate, sayfos, dimecron, ekatin, metasystox (i) to control scales, aphids, psylla, white flies, leaf miner and citrus dogs significantly induced the high population of citrus red mite. These organophosphorous insecticides could not only check those insects but also kill their predators like *Stethorus* and *Oligota* beetles, so the citrus red mite problem become very severe at present. Besides, the acaricides like chlorobenzilate and tedion were also not able to control citrus red mite which had already resisted to these acaricides.

For overcoming the above trouble, the Institute had designed some integrated control of citrus insects so called spot, skip or alternate application of insecticides when the chemical control is necessary. Otherwise, it may be left alone without spray, the population of citrus red mite will naturally go down again below the economic level.

The water soluble systemic insecticide, Azodrin painted on the bark of tree near ground at flushing could obtained a good control of most young foliage insects like *Aphis spiraecola* Patch, *Toxoptera citricida* (Kirkaldy), *Phyllocnistis citrella* Stainton, *Diaphorina citri* Kuwayama, *Chrysomphalus ficus* Ashmead and *Phyllocoptruta oleivora* (Ashmead). Meanwhile, a liberation of *Trichogramma australicum* Girault for the control of citrus dogs in such a chemical painting citrus grooves had also indicated a successful establishment. Therefore, the integrated control of citrus insects was perfectly successful in the demonstration. It could save not only the costs of water, labors and insecticides but also protecting many kinds of the natural enemies of citrus insects. In a word, it will be able to check the above young foliage insects plus *Panonychus citri* McGregor and maintain its population far below the economic level at any time.

11. Banana Insects

Banana mealybug is the most injurious insect pest of banana especially in the southern part of Taiwan. A number of them are always living in flocks by sucking the juice with their tube-like months, on almost all parts of the banana plant. Since the banana fruits are strictly prohibited from exportation at the appearance of mealybug, so the influence in reducing the income of foreign exchange is very serious.

The effective control was cleared from the results of this experiment. Both of

Diazinon e.c. and Sumithion e.c. at 0.05%, gave the excellent mortalities. The treated plot with applying 3 times was as high as 100% effectiveness.

12. Litchi Insect

Erinose mite of litchi, *Eriophyes litchii* Keifer, is one of the most serious pest in centro-southern Taiwan. As an affected leaf sometimes contracting and swelling, many orchardists mistake the erinose for a kind of diseases and name it leaf-dwarf or leaf-hypertrophy of litchi.

In our former works in 1950-1952, the best result of control is given by Lime-sulphur at 0.3-0.5 °Be, but vewing to its phytotoxicity, it is unsatisfactory to apply. From the result of this study, the best control was shown by Chlorobenzilate at 1:1,000. Sulton (wettable sulphur) at 1:300 and Pestan at 1:1000 were also very excellent.

13. Mango Insect

The larvae of mango twig borer (*Chlumetia transversa* Walker) bore into the twigs both of young shoots and inflorescences of mango trees and cause them wilting or unfruitfulness.

According to an observation of seasonal occurrance, there are two outbreaks of this insect pest in a year round. One is in March when the mango tree shoots its inflorescences, and the other is in November when the mango tree shoots its new branches. And the damage caused by the pest of first outbreak is more serious than that of the second one.

The control work consisted of spraying at branching period and blooming period. From the result, we cleared that treatment at blooming period was more efficient than that of the same at branching period. The better three among the chemicals were Sumithion e.c. 0.05%, Lebaycid e.c. 0.05% and Sevin w.p. 0.1%. It is suggested that a better time for control should begin in early January for the first outbreak, and in early October for the second outbreak.

14. Cruciferous Insects

Myzus persicae Sulzer, *Lipaphis erysimi* Kaltenbach, *Prodenia litura* Fabricius, *Phytometra ni* Hubner, *Phalaena (Tinea) xylostella Linnaeus*, *Oebia (Helluda) undalis* Fabricius etc. usually appeared at the same season in Taiwan. Rotenone combined with DDT, or malathion only, was found to be the adequate control measures.

To use high toxic insecticides on the edible part of vegetables near harvest,it induced the residue. Therefore, the department had tried on some insecticides against these insects. We found phosdrin might be a good substitute for endrin and parathion to avoid the residue problem. Anyhow, the operator still has to pay his attention on applying this chemical.

Dusting 1% r BHC 20kg per hectare when seeds of vegetables were sowed. It was the cheapest and easiest control method against turnip flea beetle, *Phyllotreta vittata* Fabricius in spring and summer season. 2 or 3 applications of 5 to 7 days interval immediately after the buds appeared were also effective. However, Sevin 50% wp 1:500 was found as the most effective method for controlling this beetle recently.

Diamond back moth, *Phalaena (Tinea) xylostella Linnaeus* is a comsmopolitan species. Its life history was observed in 1965 and 1966. It was known having 19 generations in room temperature and 18 generations in field annually. One generation took 13–34 days under room temperature and 13–37 days in field and 17–20 days under the constant temperature of 23°C respectively.

The outbreak of diamond back moth on this island mainly due to the shorter developmental period inducing the resistant strain of the insect to the chlorinated hydrocarbon and organophosphorous insecticides, or due to the extensive use of new insecticides sacrified its effective parasites, *Apanteles plutellae* Kurdj (larval parasite) and *Diadromus* sp. (pupal parasite). According to the field survey, the percentage of parasitized larvae and pupae were over 70% in non-insecticide application field, therefore, the application of insecticides was not the economical way. It might be able to obtain an economical and successful control if the microbial control by applying thuricide instead of insecticides method was adopted.

15. Melon Insect

Melon fly (*Dacus cucurbitae* Coq.) is very serious pest of cucumber. In 1957, an experiment on melon fly control was carried out. Using protein hydrolysate 0.25% as attractant and with malathion wettable powder 0.125% as insecticide in controlling the melon fly on cucumber, shown an excellent result. In the treated plots we had not only obtained 89.41% healthy fruits (check plot, 27.08%) but also obtained high yield which increased 26 times than the check plot. In order to make the farmers familiar with this control measure a largely scaled demonstrations on melon fly control was carried out in twelve Hsiens in 1958–1959, and an excellent result was given. So the gobernment has imported a great quantity of protein hydrolysate and malathion to extend to the farmers.

16. Mushroom Pests

(1) *A General Survey of Insect Inhabitants in Mushroom Nurseries*

This survey was made at 20 mushroom nurseries distributed in 10 subdistricts ("Hsing" and "Tsengs") in Chiayi, Changhwa, Taichung, Taoyuan and Taipei Districts ("Hsians"). During the process of preparing compost, the insects were sampled and collected by the use of sweeping nets (2 replications). Among the 67 species of insects collected, scavengers were dominant (Sphaeroceridae, 90.7; Lonchaeidae, 2.1%), while predators followed far behind (staphylinids, 2.0%). In average, each 100 strokes of sweeping nets produced 393~449 individual insects.

After the compost was brought into nurseries and placed on beds, specially designed funnel traps were operated over the beds and were examined at intervals of 15 days. They revealed altogether 63 species of insects, and mites, among which the mites (12 species) were most abundant, 77.2%. Less abundant were hypogastrurids, 15.8%; cyphoderids, 3.8%; and lonchaerids, 1.9%. Each square foot of bed was, in average, inhabited by 68 mites, 14 hypogastrurids, 7 other insects. Generally the populations of cyphoderids and spaerocerids were high in the later and early periods respectively, whereas that of hypogastrurids did not fluctuate much during the entire cultivation process.

Light traps were also operated from mid October to mid March inside the nurseries and totally 69 species of insects were collected, 71.3% of which were hypogastrurids; 2.7%, sphaerocerids; 8.2%, cyphoderids; 3.3%, cecidomyiids; 2.1%, staphylinids. The population of hypogastrurids reached the peak in November and was slightly lower in December; the cyphoderids were more abundant in December and after late February; the staphylinids and compost-inhabiting insects (cecidomyiids, lonchaerids, sphaerocerids, etc.) were more abundant before December.

Inside each 30 freshly emerged mushrooms, 6 cecidomyiid larvae in average were found, of which the seasonal fluctuation of population density was insignificant. On each 30 veils and stems, 14 hypogastrurids, 11 mites and 10 cecidomyiid larvae were found.

(2) *Seasonal Fluctuation of Population of Mycophila Speyeri in Mushroom Nurseries*

As a result of light-trap surveys in 20 mushroom nurseries in northern central Taiwan from October to March 1966~67, adults of *Mycophila speyeri* were found to be most abundant in November but were rare in other months. Females greatly outnumbered males in mid November while the latter sex became dominant in late November. This indicated that the oviposition and larval development of this important pest were largely in mid November. The species is more abundant in northern than in central part of Taiwan and occurs in both lowlands and hillsides.

(3) *A General Survey of Mites Inhabiting Mushroom Nurseries*

Fifteen species of mites were collected on surface of cultivating media in northern and central of Taiwan by using funnel traps. Of these 15 species, 1 was each predatory and parasitic, and Neoparasitids (larvae), *Tyrophagus putrescentia* and *Pigmaeophorus* sp. were most abundant. The population density of these mites varied with the species but generally it was at the highest from mid November to mid December. Apparently the mites were brought into the nurseries along with the compost used as the cultivation media, and the prior treatment of the compost is important to control these pests.

(4) *Preliminary Tests of Fumigation of Compost Used for Mushroom Cultivation*

These tests were undertaken in Taipei in 1966~67. Chloropicrin (dosage: 16 c.c, 24 c.c. per M^3) and phostoxin (12g and 18g per M^3) were applied for a period of 3 days. The variance analysis of the results revealed that both fumigants were very significantly effective to control mites (*Pigmaeophorus* sp.) and in the first month after fumigation, the productivity of mushrooms increased while the second month was insignificant.

17. Phytophagous Mites

Up to the present, there is only a few information concerning the phytophagous mites of Taiwan. Actually, we have already had some serious problems on the infestation of mites in agriculture.

During the past two years, we had a survey of phytophagous mites on more than three hundred economic plants or crops on this island. 3 families and 13 genera of

mites were collected as *Tetranychus, Oligonychus, Eotetranychus, Schizotetranychus, Allonychus, Eutetranychus, Panonychus, Petrobia, Bryobia* of Tetranychidae; *Tenuipalpus, Brevipalpus, Dolichotetranychus* of Tenuipalpidae and *Tuckerellus* of Tuckerellidae.

18. Miscellaneous Studies on Insect Pests of Vegetable and Fruit

The following accounts of insect pests are the accomplishments of Fengshan Tropical Horticultural Experiment Station:

Name of Insect Pests	Hosts	Insecticides & Concentration	Time of Application
Aphis (*Rhopalosiphum pseudobrassicae*)	Cruciferous vegetables	Derris e. 1–2,000 or BHC e.1–2,000	Spray when needs spray
Stem miner (*Agromyza phas.*)	Beans	25% DDT e. 0.025%	From seedling to flowering
Stripped flea beetle (*Phyllotreta si, iolata*)	Cruciferous vegetables	10% DDT dust 1% BHC dust	3 applications: once just after germination twice the successive Weeks
Cucurbit beetle (*Aulacophora similis*)	Cucumbers	Sevin W.P. 0.05%	
Banana Weevil (*Cosmopolites sordidus* Germ.)	Banana	Aldrin 0.1–0.2% Dieldrin 0.1–0.2% Endrin 0.05–0.1%	March, May, July, Oct.
Banana lace wing bug (Stephanitis *typica*)	Banana	Sevin W.P. 0.05%	

E. Insecticide Toxicology

1. Manufacturing Rotenoid Emulsion

Since *Derris elliptica* Benth and var. were introduced from Singapore as a useful botanical insecticide. The department first carried out to study and manufacture rotenoid emulsion for local consumption to control vegetable and other crop insects especially in killing aphids in place of hand crushing derris extract.

The rotenoid emulsion was prepared from ground derris root powder which had been passed through 80 mesh already, then extracted in acetone at 60°C until 12 hrs and evaporated into brown colloidal residue. The residue or rotenoid total extracts, besides the isecticidal elements of rotenone, deguelin, tephrosin, sumatrol, toxicarol and also having noninsecticidal resin, pigments and uncrystalized materials.

The extracted brown colloidal residue was dissolved in brown camphor oil B emulsified with C–S emulsifier (monopol, saponified castor oil) added an antitoxidant 1.5% b–naphthol and kept in tight colored containers at cold place ready for use. Its insecticidal value was still stability within two years.

Rotenoid emulsion plant was established in 1949 and reorganized under China Farmer Bank control in 1950 to now. The daily production is about 100 lbs.

2. Insecticide Toxicology

Insecticides DDT, gammexane, rotenone and acid lead arsenate were tested. Larvae of *Bombyx mori* L. (Bombycidae), *Philosamia cynthia ricini* Boisduval (Saturnidae), *Notolophorus australis posticus* Walker (Lymentriidae) and *Prodenia litura* Fabricius (Noctuidae) were chosen as an experimental insects under leaf sandwich method of Campbell (1930). The stomach poison of the tested larvae differed from each other. Theri lethal dose (L.D.50 mg/gm) were noted in below:

Bombyx mori: rotenone (0.003)>gammexane (0.005)>DDT (0.044)>acid lead arsenate (0.075).

Philosamia cynthia ricini: rotenone (0.006)>gammexane (0.019)>DDT (0.024)> acid lead arsenate (0.071).

Notolophorus australis posticus: gammexane (0.023)>rotenone (0.025)>DDT (0.099)>acid lead arsentate(0.156).

Prodenia litura: gammexane (0.018)>DDT (0.118)>acid lead arsenate (0.218)> rotenone (recovery from dose as high as 0.6).

The relative toxic action of the four tested insecticides against the four species of Lepidopterous larvae was also observed. After making the administration of DDT and gammexane sandwiches, the insect ensued vomitted yellowish green gut juice within a couple of hours and the anterior part of the body moved continuously in left and right directions. The symptoms of toxicity involved increased activity eventural appearance and persistence of contruction and tremors in the body, and finally lost body equilibrium. The speed of toxic action of gammexane is faster than that of DDT.

After taking the dose of acid lead arsenate by oral ingestion, the insects stopped feeding fresh leaf, the dark party pellets were voided quite frequently, the larvae become gradually weakened and died after 24 hours.

The susceptibility of the insects to rotenone is rather slow and mild in that the insects usually consumed much more than their lethal dose, without showing any symptoms.

3. Oral Toxicity of Lindane and Its Tolerance to Poultry and Mice

Animals used for oral administration test were leghorn chickens, hybrid native ducks and D–D strain mice. All the diets were throughly mixed lindane impregnated dust at the concentrations of 2,4 and 10 ppm respectively. The tested animals were fed daily and continuously for 3 months. The body weights of the tested animals were recorded individually at every one week or ten day interval in comparison with that of the check feeding in normal diets. The gains of body weights of each animal in the treatment were shown no difference. After three month treatment, the animals were sent for the gross anatomical examination. In the case of mice, these sections

from feeding in varying concentrations of lindane contained diet were also checked with the visera tissue under the microscopic histological examination. All the results showed to be normal.

4. Insect Resistance to Insecticide

DDT, toxaphene, aldrin, lindane, chlordane and dieldrin were tested. The adults of *Dacus cucurbitae* Coq. after exposure three hours on filter paper with different insecticides at certain dosages mg/ft², and found out their LD 50. The chemicals tested were DDT 50 mg/ft², toxaphene 30 mg/ft², aldrin 1 mg/ft², lindane 1 mg/ft², chlordane 2 mg/ft² and dieldrin 1.5 mg/ft² respectively.

After test, the percentage of mortality was recorded and alive flies were then reared again in the insectary upon emerged flies for next generation, they were still exposed to the same dosage of the same insecticides again respectively. After passing 15 generation exposure and selection. The mortality was gradually reduced 7 in DDT, 3 in toxaphene, 2 in aldrin, 1 in lindane, 0.2 in chlordane and 2 in dieldrin times compared from first exposure respectively.

5. Bioassay of Pesticide Residue on or in Vegetables

Bioassay of pesticide residues on or in marketing vegetables have been carried out since August, 1959, using *Culex fatigans*, *Lebistes reticulatus* and *Drosophila melanogaster* for the tests, since *Culex* is very sensitive to paration and *Lebistes* to endrin. Until 1959, leaf mustard, Chinese cabbage, cauliflower, broccoli, spinach, allium, water convolvulus, string bean, asparagus bean have been tested. The test method was that of K.R. Elliott (1956) and W.A. Gersdorf process was used as testing method. Up to the present have not found any case exceeding the international tolerance limit set for the regulation of pesticide residues.

6. Sumithion and Parathion Residues on Rice and Green-Stem Cabbage

The stabilities of sumithion and ethyl parathion residues on growing rice crops and green-stem cabbage were compared in this study. The averel noris colorimetric method and the dry film method with three-day old house flies were used for chemical analysis and bioassay respectively. The results of the analysis indicated that sumithion was easier to be decompossed than parathion. Therefore based on the consumers' safty, it seemed that sumithion was safer than parathion, sumithion should be recommended to take the place of parathion in practical field use.

7. The Removal of Parathion Residues from Cabbage Leaves by Washing and Cooking

Cabbage was used as the testing material for this study. The cabbage were grown in a field of the Institute. No insecticides was used during the growning period. After harvest, parathion was applied by the dipping technique with rates of 15 and 10 ppm, 300 gm of each rate of the chemical was dipped evenly on the underneath surface of the testing cabbage leaves.

After air dry for 12 hours, the leaves were washed with running tap water for 5 minutes, the other treatment was: fried the cabbage in lard, cooked with water or dipped them in Amikan-K or Li-Tai detergent. The chemical analysis was made by

the colorimetric method developed by Averell and Norris. Three-day-old *Musca domestica* and dry film method were used for bioassay.

Results showed that washing reduced the residues to a low-level, samples with 15 and 10 ppm of parathion reduced 39, 42 and 52% respectively after the treatment. Samples dipped both in Li-Tai detergent and amikan-K reduced most the residue too. The reduction of residues was significant after cabbage was fried in lard or cooked with water. Residues in soup were higher than that in cooked cabbage. Parathion residues on cabbage could be reduced by the treatments tested in these experiments, however, none of the treatments could be removed the residues below the tolerance rate of 1 ppm, if the initial residue is 10 ppm.

Results of bioassay as well as chemical analysis indicated the possibility of removing or reducing by washing and cooking methods. It seemed that chemical analysis method could detect more residues than bioassay. Though existance of nitro radical in hydrolyzed parathion was mostly moved with sodium bicarbonate solution. This might be explained the chemical analysis and bioassay which showed the degree difference of elimination.

8. Bioassay of Marketing Pesticides

This routine work was started in spring, 1959. The insects used for testing included adults of *Musca domestica*, *Sitophilus oryzae*, larvae of *Culex fatigans*, *Prodenia litura* and *Philosamia eynthia ricini*. The fungi and bacteria used for testing included *Piricularia oryzae*, *Cochliobolus miyabeams*, *Pellicularia sasakii* and *Bacillus cereus*. Spray, microinjection, paper disk and spore germination methods were used for testing. More than 2571 samples have been inspected from 1959 to 1967.

VI. Agricultural Engineering

A. Experiments and Study on Power Tillers

The draft oxen were far from sufficient in Taiwan in early 1950's. The government authorties concerned took that situation into consideration and had imported various kinds of power tillers from Japan as well as from the United States so to meet the necessity of farmers in Taiwan. But the trouble was what kind or kinds of power tillers should be adopted to Taiwan? this was the urgent problem which had to be solved at the very beginning. The department of agricultural engineering of this institute had its first chance to play a big role in Taiwan's agriculture and had been taken a great effort to test and study various kinds of power tillers and attachments to decide which kind or kinds of power tillers should be adopted in Taiwan. And this was the first and magificent work that this department had been achieved in the early days of Taiwan's farm mechanization. The power tillers used in Taiwan today are still based on the experiments which this department had worked out. Besides, this department had also been tested many farm tools to replace the old ones in the past decade.

B. Experiments and Study on Hand Rice Cutters and Portable Power Rice Cutters

Farmers in Taiwan used to harvest rice grains by using sickles to cut the rice culmrs down first and with a threshing machine for threshing afterwards. This old fashioned harvesting procedures not only will take great pains for farmers themselves but also will take a long time to do it during harvest season. Since this country had been industrialized step by step during the past decade, and the national economy has been prosperous, the rural population has decreased rapidly and most of them being transferred to be industrial population in urban area, hence, the rural area is facing an increasly acute shortage of labour at present, and the situation will be certainly worsen when the time passes by. By reviewing the whole situation, this department has engaged in studying and experimenting the hand rice cutters and portable power cutters so that we can improve this situation to a certain extent or to use less man power to finish this kind of works at present days.

C. Experiments and Study on Rice Combines

Since the rural population has been decreased and the man power is in short for farm works, it is certain that the hand rice cutters or portable power rice cutters which are under study at this department wont solve this problem at large. That is to say, they are not the ideal tools for farmers in Taiwan in the long run. Hence, it is a matter of fact that the rice combines should be adopted as soon as possible. Hence, this department is also engaged in the study and experiment of the rice combines. Since there are still a lot of problems unsolved, it seems that the rice combines may be not adopted by the farmers in Taiwan in the near future, but it is the topic that we should study as well as the urgent problem that we should solve as early as possible in the benefits of the farmers as well as the whole country.

D. Experiments and Study on Circulation Dryer

It is too bad that the first crop in central and southern Taiwan as well as the second crop in northern Taiwan are in the rainy season. Usually, farmers in Taiwan are drying their rice grains simply by spreading the grains on the ground under the sun. Since the weather is not dependable, a continuous rain will not only cause much inconvenience and trouble to the farmers, but also even cause heavy losses or even make the harvest fruitless to them. This department had taken this situation into account, and had studied and experimented various kinds of dryers such as (1) forced air downward-flow dryer; (2) forced air upward-flow dryer; (3) inter-flow dryer; and (4) circulation dryer to solve this urgent problem. Right now, we have found that the circulation dryer attached with a kerosen stove may be the best one among them. The basic study and experiment has been already completed.

E. Experiments and Study on Power Tillers and Tractors

Since the standard of living in rural area has been improved and the young ones in the country side are also well educated, with the rising production cost and its resultant lowering farm income have been driving farmers to industrial cities, as industrialization proceeds, still more people will move away from the country side, and agriculture will face an increasingly acute shortage of labour, hence, it is certain that the agricultural structure at present days will be changed in the near future, and the joint-operation farms which are aimed at increasing production and reducing cost will be much more popular in Taiwan. And the good labour saving method for farm works as well as large-scale farm mechanization will take much into account to a certain degree. By pooling labour and other resources, a large farm can increase agricultural products with good quility. Farmers who are freed from their daily chores by mechanization will have more time to develop sidelines, like agricultural process, and so on. Hence, it is certain that tractors with a big horse power will be adopted by farmers along with power tillers. By take this situation into consideration, this department has already engaged in years in this kind of study which aims at large-scale farm mechanization for the future in Taiwan.

F. Study of Fiber Processing Machines

Three types of decorticating machines operated by power have been designed by the Tainan Fiber Crops Experiment Station. Another manual-operated type, called the Koa-pen type, has been designed by professor Koa-pen of the National University. The Koa-pen type has been used for ramie production in mountaineous villages.

The Raspador type decorticator for kenaf was imported from Japan and modified by mounting two wheels on it to be towed by a power tiller so that it can move conveniently in the producing area. It is expected that the decorticated kenaf will replace jute in weft yarns or be blended with retted fiber for making gunny sacks in order to reduce the cost of production. According to trials in Taiwan, the yarns containing decorticated kenaf were substantially stronger than those made purely of retted fiber. The upper part of retted fiber is usually weaker due to overretting. Therefore, attention should be paid not only to fiber processing by this machine but also to gunny sack mills using such decorticated fibers in order to improve the quality of

their products.

Fiber washing machine for jute and kenaf was developed by Mr. Virgil G. Pettit and reproduced in Taiwan in 1960. Some modifications and improvements were made during the trials. Labor required for each kg. of dry fiber was reduced from 0.193 man-hour to 0.165 man-hour, a saving of about 20%. The retting period was shortened in summer from 9 days for hand washing to 5 days for machine washing, and the product was also stronger due to the elimination of overretting. The machine washed dry fiber was softer and cleaner than hand-washed fiber. Because of these advantages, further improvements on the washing machine should be made in order to increase its efficiency.

Deseeding machine for jute seed and splitting machine for banana pseudo-stalks have also been designed by the Tainan Fiber Crops Experiment Station. The characteristics and performance of the above mentioned machines are listed as follows:

The Character and Efficiency of the Fiber Machines in Tainan Fiber Crops Experiment Staion

Kind of Machines	Manufacturer	H. P. Required	Efficiency (kg/8 hours)	No. of Labourers for Operating
Tainan F.C.E.S. TypeA Power Decorticator	Local Factory Improved and Superintended by F.C.E.S.	4—5	Ramie 120 Sisal 240 Banana Pseudo-Stalk30 Pineapple Leaf Fiber 15	5—6
Tainan F.C.E.S. Type B Power Decorticator	Local Factory Improved and Superintended by F.C.E.S.	3/4—1	Ramie 45	2—3
Tainan F.C.E.S. Type C Power Decorticator	Local Factory Improved and Superintended by F.C.E.S.	5—7	Jute Fresh Crude Fiber 5,000	5—6
Tainan F.C.E.S. Kau, Pan Type Pedal operating Decorticator	Local Factory, Designed and Superintended by F.C.E.S. and National Taiwan University	Human Labor	Ramie 16—20	2—3
Fiber Washing Machine	Designed by V. C. Pettit of USDA Reproduced and Improved by F.C.E.S. and National Taiwan University	4—5	Retted Jute 200—240	3—4
TainanF.C.E.S. Splitting Machine For Banana Pseudo-Stalk	Local Factory, Improved and Superintended by F.C.E.S.	4—5	Banana Pseudo-Stalk 1000—2000 Stalks	2
Tosan Type Ramie Brushing Machine	Toyo Sen-I Company, Japan	4—3	Ramie Dry Fiber 50	2
Raspador Type Decorticator	Kawahara Giken Sangyo Co. Japan	7—8	Kenaf Unretted Fiber 250	5—6
Cotton Roller Gin	Asai Iron Works Japan	2—3	Seed Cotton 200—300	2
Flax Seeding Machine	China Agricultural Machinery Co. Ltd. Improved by F.C.E.S.	Connect With 7—8 H.P. Driven Tiller to Seed	Seeding Area 0.7—0.8 ha	2
Jute Seeding Machine	China Agricultural Machinery Co. Ltd. Improved by F.C.E.S.	Connect with 7—8 H.P. Driven Tiller to Seed	Seeding Area 1.2—1.5 ha	2

Finally, ox and tiller seeding machines for jute have also been designed by the Tainan Fiber Crops Experiment Station. According to the test report, ox-seeding machine can save 1/2 of human, and animal labor and 1.6% of jute seed loss. The tiller seeding machine for jute will be studied and tested in Taiwan villages.

G. Testing of Fiber Qualities

Machines for testing fiber qualities have been installed. They are used for testing tensile, shearing, wearing, flexibility and fineness. The temperature and humidity in the laboratory may be adjusted to 70°F And 65%, in order to test the qualities of fibers and cloth accurately.

TARI LIB.
W007780